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New Underground Trunk Lines of the American Telephone and Telegraph Co.*

The American Telephone & Telegraph Co. at present is completing the work of placing underground its telephone wires for various service between Boston and New York, New York and Philadelphia and between Philadelphia and Washington. When this work is completed, a recurrence of the conditions which existed after the storm of March 4, 1909, will be prevented. It will be remembered that then, which was the time of President Taft's inauguration, Washington was completely isolated from the rest of the country, so far as telephone and telegraph service went. For several years underground cable between New York and Wilmington has been in service. The final link needed to connect New York with Boston is the section between New Haven and Providence, work on which is already under way. The stretch of cable between Wilmington and Washington is now being installed in an underground conduit which has recently been completed. This line is approximately 110 miles long and passes through Baltimore.

The stretch of underground conduit between Boston and Washington, it is expected, will be completed some time in the present year. The company has other work projected which involves the expenditure of great sums of money and requires many years for completion. When this is finished the chances of isolating any of the important cities of the eastern seaboard will have been practically eliminated.

Many years ago, when it was apparent that the trunk lines for telephone service between important centers must be put underground to ensure against interruption from storms, the engineers of the telephone company undertook the problem of providing an adequate number of circuits to handle a growing business and of securing a practical effectiveness sufficient to permit of satisfactory connections to the regular city and suburban subscribers at each end, at reasonable cost. Up to the present time, the longest commercial circuits wholly underground are those between New York and Philadelphia—something less than 100 miles. The step from this distance to the 235 miles between New York and Washington involved still more engineering development. The success which has been secured in balancing the many conflicting electrical conditions is partially disclosed by the fact that the cable now being installed in the conduit between Washington and Philadelphia has the same outward appearances and dimensions as the existing cable between New York and Philadelphia, but provides a grade of communication nearly identical with that now furnished between New York and Philadelphia.

*From information furnished by the American Telephone & Telegraph Co., 15 Dey St., New York City.

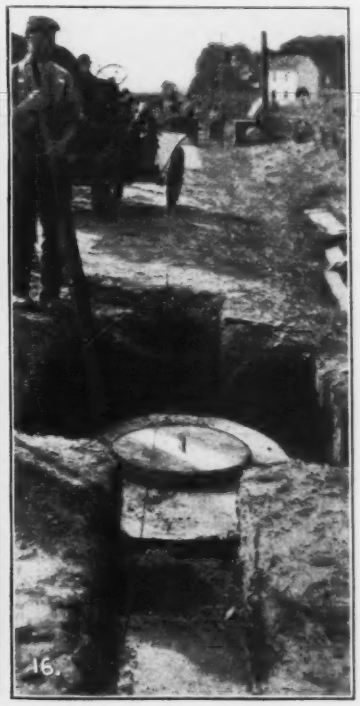


Fig. 14. Test of Side and Roof Slabs. Fig. 16. Completed Manhole.
Fig. 15. Manhole Being Built Up in Trench.
CONCRETE MANHOLE CONSTRUCTION; AMERICAN TELEPHONE AND TELEGRAPH CO.

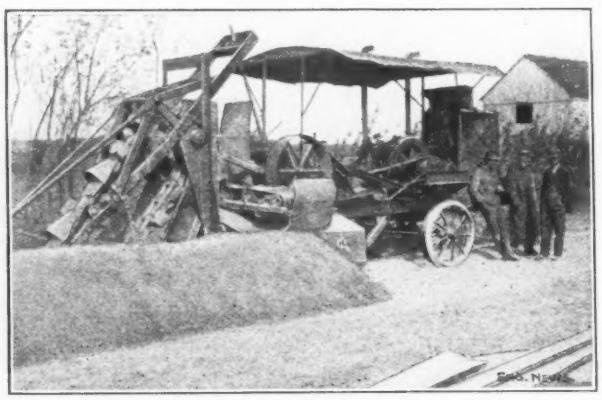
The work of laying conduit to receive the cable involves methods of interest on account of the long stretches which have to be laid continuously, presenting opportunities for rapid and economical methods. These are well shown by the work between Wilmington and Washington.

The engineers of the telephone company, long before the actual undertaking was decided upon, had studied the route and made preliminary and location surveys. It is of interest to note that the route followed is that over which Prof. S. F. B. Morse, the inventor of the telegraph, planned to lay an underground telegraph line in the forties. Plans had to be completed for a trench along the highways, approximately 100 miles long, and for the crossing of 75 bridges, each of which had its own peculiar problems. The best methods for each situation had been carefully studied and the procedure fixed before work was started.

TRENCHING AND BACK-FILLING.—The work of trenching was split into three sections and let to contractors. Section 1 extended from the southwesterly line of Wilmington to the west bank of the Susquehanna River at Havre de Grace. Section 2 extended from the west bank of the Susquehanna to the northeasterly line of Baltimore. Section 3 ran from the southwesterly line of Baltimore to the northeasterly line of the District of Columbia.

On section 1 a "caterpillar" trenching machine (Austin type) was successfully used by the contractor. The record of the telephone company's engineers showed that this machine (Figs. 1 and 2) excavated daily 1,000 ft. of trench, 18 ins. wide by 3 ft. deep, work which would have required some 50 laborers with pick and shovel. The capacity of the machine was found to be about 3 ft. of clean trench for each minute of actual working time. For operation, an engineer and two assistants were required.

On other sections, a trench plow was used, as shown in Figs. 3 and 4, drawn by two mules or horses, sometimes driven abreast and sometimes in tandem. The



FIGS. 1 AND 2. AUSTIN TRENCHING MACHINE AT WORK IN THE WASHINGTON-WILMINGTON TELEPHONE-CONDUIT LINE.

first plowing was usually made for a depth of a few inches only and for a distance of about 300 ft. Then shovelers were put on to throw out the dirt while the plow was breaking up another 300-ft. section. This operation was repeated until the required depth was reached. Frequently the team was driven tandem in the trenches. After the ducts had been laid, 6 ins. of dirt was carefully filled in around them and tamped. Then a trench roller (Fig. 5) was put on and followed by a layer of 6 ins. of dirt, which was tamped and rolled. This process was continued until the trenches were filled. Finally a 1,000-lb. horse-drawn road roller was used to pack the back-filling as solidly as possible.

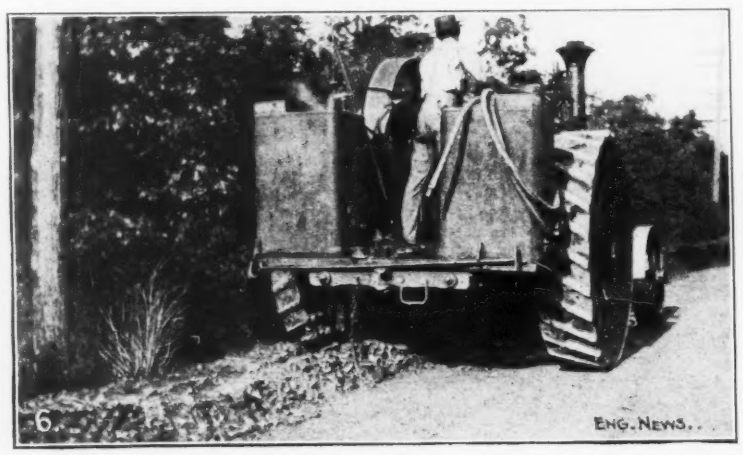
On Section 2 the earth was back-filled loosely and crowned about 6 ins. above the roadway. Then a 10-ton steam roller (Fig. 6) was put on and the trench rolled until thoroughly settled. On Section 3 a scraper was used to expedite the trench filling, as shown on Fig. 7.

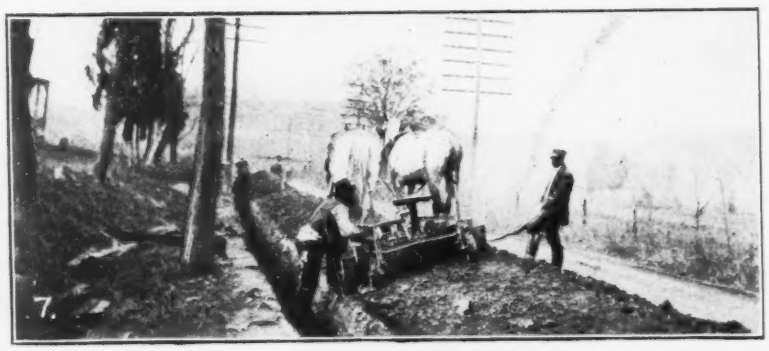
Many of the highways between Baltimore and Washington are improved roads, having a 14-ft. strip of macadam in the center. Some of these roads had been oiled, and it was feared that the ordinary work on the trenches might seriously damage the surface. To prevent this, strips of burlap 8 ft. wide were used to cover the road while the work of trenching was going on. These strips were laid for 3,000 or 4,000 ft. at a time. Dirt from the trenches was thrown on the burlap (as in Fig. 3) and the surface was easily and perfectly cleaned up after back-filling. Then the burlap was removed and transferred ahead to another section.

Fair digging was generally encountered and all large rocks and ledge outcrops were removed by a rock gang without delaying the progress of the work generally.

CONDUIT.—The conduit, as laid down in the trench, consists of four separate ducts, except when passing through towns when the number is increased to five or six. The ducts are commonly known as "pump logs" (see Fig. 9). They are timbers of Southern yellow pine, 4½ ins. square and 7 ft. long, having a circular hole 3 ins. in diameter. Usually they are laid two-high or to form a square conduit, but this is changed as necessary, as in Fig. 13.

For preservation against rot, the log ducts are





Figs. 3 and 4. Trench Plowing.

Fig. 5. Concrete Roller for Trench Work.

Fig. 6. Rolling Conduit Trench With a 10-Ton. Steam Roller.

Fig. 7. Scraper for Trench Filling.

Fig. 8. Burlap Used to Protect Oiled Macadam.

FIGS. 3 TO 8. TRENCHING AND FILLING ALONG THE WASHINGTON-WILMINGTON CONDUIT LINE.

creosoted by the pressure process, the standard of requirement being 15 lbs. of dead oil of coal tar per cubic foot of wood. The ends of the logs fit together in a simple slip joint requiring no cement. These wooden ducts have been found very durable. For instance, a line laid in Philadelphia in the early '80s was recently dug up and found to be practically intact; indeed, the logs recovered were later used in another place. For the Wilmington-Washington trench, something over 300,000 pieces of log duct were required.

FIG. 9. TELEPHONE CONDUIT IN PLACE.

BRIDGE CROSSINGS.—Running the telephone conduit across a bridge involves several problems: (1) it must not interfere with traffic; (2) in case of a railroad crossing the ducts cannot be suspended where they would reduce the head room over freight cars; (3) they must not be suspended at a river crossing, so that spring freshets can force debris against them, if at all avoidable, and (4) they must be protected from general damage in every possible way.

In many cases the crossing was made by encasing the ducts in a wooden box of heavy creosoted plank supported by an angle iron or suspended by iron hangers from the bridge structure. In some cases as in Fig. 11, the angle iron has been laid across the bridge girders beneath the flooring, the ducts running on wooden blocks placed at intervals on the angle iron. The ducts are then protected from abrasion by the flooring with a wrought-iron plate on the top and sides (Fig. 11). Where it has been necessary to suspend the ducts from the side of the bridge (Fig. 13), the approach has been made on a vertical curve using iron ducts protected by concrete construction. Similar methods were necessary where sharp horizontal curves were encountered, as shown in Fig. 12.

The old method previously employed to protect the cables at bridge crossings was the simple use of iron pipe. This construction has been avoided on the Washington-Wilmington line wherever possible as it has been found that the iron pipe rusted and disintegrated within a few years. On only six out of the 75 bridges on this line was it necessary to use the old construction.

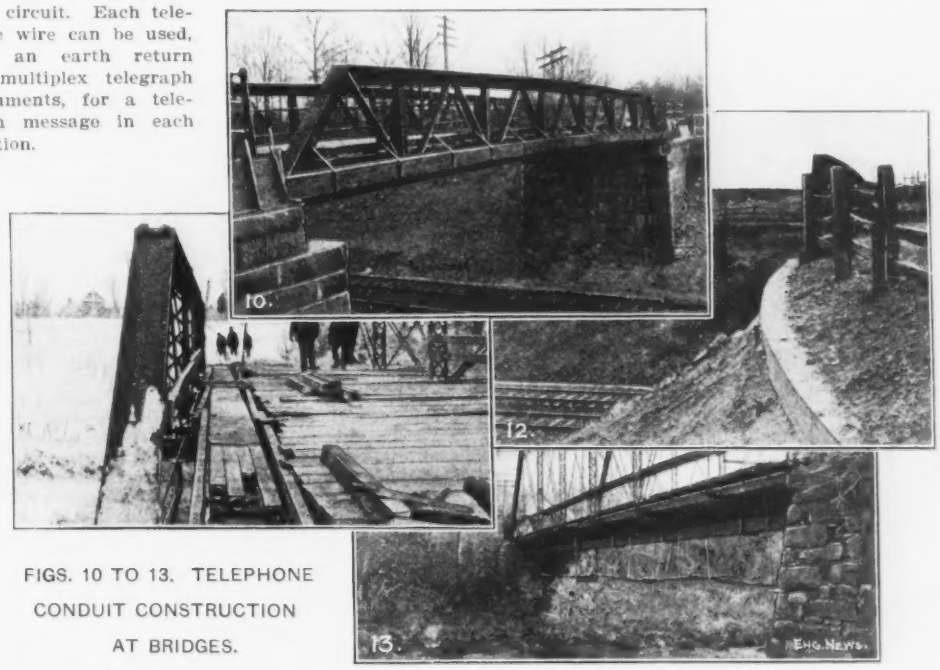
MANHOLES.—About every 500 ft. along the conduit a manhole has been constructed for convenience in drawing in the cables for testing for faults, repairing damages, etc. The manholes used on this line are an innovation, being built up entirely of concrete pieces, a substitution for the bricked-up type with an iron cover.

This manhole is barrel-shaped, 3 ft. wide by 4 ft. 6 ins. long, with 3 ft. of head room. The walls consist of four curved concrete slabs 3 ins. thick, reinforced with expanded metal. The wall slabs are comparatively thin and are held in place by heavier key blocks shown in Fig. 6. By using these key blocks the conduit can enter the manhole at any convenient height without special work. The roof is formed by two reinforced slabs 4 ins. thick. There is no base and the manhole has a dirt floor. A flanged cover, 24 ins. in diameter, is also made of reinforced concrete. These several parts are shown in Figs. 14, 15 and 16.

The manhole cover, when in place, is 12 ins. below the road grade. A concrete post, 4 by 6 ins., is set 2 ft. out of the ground at the side of the road to mark the exact position of the manhole. On each of these posts is stenciled the number of the manhole and its exact distance from the marker.

To keep the supply of manhole materials ahead of the conduit installation, it was necessary to turn out 25 complete manholes daily. A concrete mixing plant was established at Baltimore, where a suitable old building was temporarily secured, located on the main line of the Baltimore & Ohio R. R., where a siding was available for loading freight cars. Some 400 pieces of reinforced concrete were cast here every working day. As 1,000 manholes were required for the line, 16,000 pieces of concrete had to be made. Forty men were employed in the plant during operation.

CABLE.—It has been stated that the outward appearance and dimensions of the new cable being installed in the conduit between Washington and Wilmington are the same as those of the cable now in use between New York and Philadelphia. The copper wires forming the circuits are insulated with paper and arranged in pairs, but otherwise the cable itself is radically different from any before installed. The wires are larger than those now in use and are so arranged that from each two pairs of large-gage wires (No. 10 B. & S.), it is possible to obtain simultaneously three complete telephone and eight complete telegraph circuits. The third talking circuit, made up by using the other two pairs as its two wires, is known as a "phantom" circuit. Each telephone wire can be used, with an earth return and multiplex telegraph instruments, for a telegraph message in each direction.



FIGS. 10 TO 13. TELEPHONE CONDUIT CONSTRUCTION AT BRIDGES.

In addition to the trunk wires there are in the lead sheath a considerable number of pairs of smaller gage wires (Nos. 13 and 16 B. & S.) for use between intermediate cities along the line, and these small-gage wires may also be used for telegraphing. The cable contains, all told, 148 wires capable of giving simultaneously 99 telephone and 296 telegraph communications. The protective covering is the usual lead (3% tin) pipe, which is in this case 2 9-16 ins. outside diameter.

The section of cable now being laid between Philadelphia and Washington requires about two-thirds of the cable between New York and Washington and will require nearly 1,500 reels of completed lead-cased cable having a total weight of about 3,000 tons. This cable is being manufactured by the Western Electric Co. in Chicago, and for its shipment to the several points of installation along the conduit line about 120 freight cars will be needed. The individual lengths average about 500 ft. (the distance between manholes). About 1,500 splices have to be made in these manholes involving about 1,250,000 wire joints. To make the wire joints and to seal the lead sheaths at each splice requires two men's time for an entire day, and the work must be done in good weather.

Of the 3,000 tons weight of cable, 900 tons are contributed by the copper conductors in the form of over 20,000 miles of wire. About 1,700 tons come from the weight of the lead (3% tin) sheathing. The paper for insulating the individual wires weighs about 140 tons and is in the form of ribbon having a total length of 24,000 miles.

LOADING COILS.—At intervals along the cable are connected 10,000 Pupin "loading" coils which introduce the proper amount of self induction to overcome the excessive capacity effects of the cable, which, if not balanced at proper points would distort and attenuate transmitted speech or require much larger conductors to secure effective communication. These coils have a low resistance copper winding of 1,500 turns over an iron core. The latter is a laminated ring, made by winding very fine Norway iron wire on a ring form. The "loading" coils are contained in cast-iron cases to be installed in manholes at the calculated points along the cable. The distance of 500 ft. between the manholes allows a maximum discrepancy of ±250 ft. from the theoretically indicated point of loading—a negligible distance compared with the distance between two coils on a given circuit.

When the cable is installed there will be 9,603 loading coils (in 388 cast-iron pots), in the 135.3-mile section between Philadelphia and Washington. There are already on the New York-Philadelphia section of 86.7 miles, 6,138 coils in 248 pots, though of a somewhat different type from that to be used on the new cable. These new loading coils, in cases complete, weigh several hundred pounds so that their installation becomes an appreciable task. The copper windings for the coils on the Washington-Philadelphia section aggregate 1,370 miles and the other copper conductor in stub connections mounts up to 6,720 miles. In all there will be 34,200 lbs. of core wire and length of 155,000 miles. The time req[illegible] of the drawing of this amount of wire would [illegible] to this cause. for the entire fine-wire department [illegible]es, 11.5%; fire, [illegible]ling's works. and rocks, 6.6%; chief among which

The conduit has been complete[illegible] leaks, 21%. of the cable has begun. But p[illegible] manufacture have been going

months. A new plant had to be installed in the works of the cable company (Western Electric Co., of Chicago), stocks of material had to be accumulated and preparations made for turning out cable and loading coils to allow the field force to install something over two miles a day, without the necessity of first accumulating a cumbersome stock.

Recent Increases in the Transmission Efficiency of Long-Distance Telephone Circuits.*

By BANCROFT GHERARDI,† M. Am. Inst. E. E.

Since June, 1900, when Prof. Pupin took out his patents for loading, practical applications of loading on a very extensive scale have been made in the plants of the American Telephone and Telegraph Company and the associated companies, and most gratifying results in improved transmission and economy in first cost of construction have resulted. At first the work done dealt with the loading of ordinary open wire lines and standard cables. Later, attention was directed to the more complex problem of loading phantom circuits and high grade No. 8 circuits and to the design of special cables for phantom circuit working in connection with loaded cable conductors.[1] As a result of the work which has been done along these lines during the last two years some very remarkable improvements in the transmission efficiency of long lines and cables have been made. The New York-Denver circuit which is now in operation and the Boston-Washington cable which is in process of manufacture have been made economic possibilities by these advances.

It may be safely stated that the cost of such work, as it would have had to have been done with our knowledge of two years ago, would have been so great as to have been commercially prohibitive.

THE NEW YORK-DENVER CIRCUIT.—The New York-Denver circuit has a length of a little over 2,000 miles.

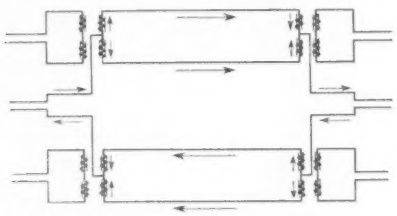


Fig. 1. Use of Phantom Repeating Coils, American Telephone and Telegraph Co.

Until the development of the New York-Denver circuit, the New York-Chicago (950 miles) and the New York-St. Louis (1,050 miles) circuits represented practically the limits of long-distance transmission. Now service from New York to Denver can be given which is as good as, or even better than, the service given a year or two ago from New York to St. Louis or Chicago, and this without using any heavier wire than was formerly employed. All our old circuits from New York to Chicago and St. Louis were No. 8 B.W.G wire, weighing 435 lbs. to the mile. No heavier wire is used to get the New York-Denver service.

One of the aims of our President, Mr. Vail, is to give universal service. The first step in the direction of giving such service is obviously to be able to give transcontinental service—that is, a talk from New York to San Francisco. It was a long step from Chicago to Denver. One more step, a little longer, will take us to San Francisco.

Two years ago we did not know how to successfully load No. 8 circuits, how to commercially phantom No. 8 circuits, or how to combine phantoming and loading. Since that time we have found out how to do all of these things, and it is as a result of these developments that the Denver circuit is a reality today.

LOADING NO. 8 CIRCUITS.—The problem of loading No. 8 circuits was primarily a problem in connection with the insulation of the line wires. A No. 8 circuit can be loaded with the same coils used on No. 12 circuits, and these coils would be spaced in the same manner, that is, at 8-mile intervals. It has been a fact, known to us ever since we started to do commercial loading, that low insulation on a loaded circuit has a much greater effect in impairing the efficiency of such a circuit than the same insulation has on an unloaded circuit. It has also been known that the effect of low insulation on the No. 8 circuits was much more serious than on the No. 12 circuits.

It having been established that a substantial improvement would have to be made in the insulation of No. 8 circuits in order that they might be successfully loaded, a study of line insulation conditions was made to determine what steps would be necessary. Aside from the general insulator leakage two particularly weak points were found in the insulation of open wire circuits.

One of these was at transposition points. With this arrangement there is a direct leakage path from one wire to the other during wet weather. The part of the insulator surface protected by the petticoat is the only part that is of much value during wet weather. Measurements showed that the leakage on lines equipped with standard single-pin type transposition insulators was 20% greater during wet weather than on lines where the two wires were never allowed to be on the same pin. The method of overcoming this difficulty was to transpose the wires without bringing them onto the same insulator. This is accomplished by employing the phantom transposition bracket for transposing a physical circuit.

Another point at which it was found that there was considerable leakage was where, for the purpose of inserting loading coils, connecting with a test station, or for any other reason, the wires were bridled. These places were particularly bad during wet weather, especially after the bridle wire had been in service for a short time and had weathered. The braid on the bridle wire soon becomes weathered and when wet is a fair conductor. Leakage takes place easily over the wet surface at the end of the rubber insulation and thence to the wet braid. This difficulty was overcome by a very neat petticoated sleeve, known as a bridle-wire insulator.

It was thought desirable on the first of these loaded No. 8 circuits to use a line insulator that would be more efficient than our standard glass insulator. After a careful study it was decided to try on these circuits a double petticoated porcelain insulator. Tests extending over a period of several years have shown that the new insulator is several times as good in wet weather as the standard insulator. Part of this improvement is due to the design of the insulator, and some is attached to the use of porcelain.

PHANTOMING NO. 8 CIRCUITS.—The problem of phantoming No. 8 circuits is one in phantom repeating-coil design. To meet the special conditions existing in connection with the phantoming of loaded No. 8 circuits as used in our plant, it was desirable that apparatus should be developed of the highest possible transmission efficiency. In order to do this the ringing efficiency of the phantom coil was sacrificed and special means for ringing through these coils had to be adopted. In this way and by specially designing a coil to meet the circumstances of these circuits, coils that were suitable were developed. The manner in which these coils are used in phantoming a circuit is shown in Fig. 1.

THE LOADING OF PHANTOM CIRCUITS AND THE PHANTOMING OF LOADED CIRCUITS.—Up to very recently, while we knew how to phantom ordinary circuits, it was impracticable to phantom loaded circuits because the loading coils so unbalanced the phantom and so increased its effective resistance that a phantom circuit created out of loaded circuits could neither be made quiet nor made efficient from a transmission standpoint. This problem is one of loading-coil designs. The reasons why ordinary loading coils were unsatisfactory when used on circuits which were to form parts of a phantom will first be stated.

Fig. 2 shows the arrangement of the windings on an ordinary loading coil. The arrows show the direction in which the current flows in the windings at a given instant and the direction of the corresponding magnetizing forces in the loading coil core. If the windings are distributed uniformly over the core, such an arrangement as this produces no external magnetic field.

The second part of this diagram shows the same loading coil and the conditions which would exist in it with reference to the telephone current flowing in the phantom circuit. This current, of course, passes along the two sides of the physical circuit in parallel. It will, therefore, magnetize the two halves of the loading-coil core in opposite directions. This will produce magnetic poles at the two sides of the core and a great amount of magnetic leakage at these points.

The results of this magnetic leakage, which would be different in different cases, would be to make it impossible to get the two side circuits sufficiently alike so as to balance the phantom; would introduce substantial cross-talk due to the stray magnetic field affecting other loading coils, and would bring in serious losses because this stray magnetic field would pass through the solid iron of the loading coil case, bringing in hysteresis and eddy current losses.

In order to overcome this difficulty, it was necessary to devise special arrangements of the windings on the loading coil so that while the coil would still be effective in respect to the current flowing in the physical circuit, the effect of the current flowing in the phantom circuit would be such as not to magnetize the loading coil core. These windings had not only to be balanced magnetically, but also to be so arranged that the electrostatic capacities between the various windings of the coil would not unbalance it. Such coils were devised and are now in successful use on the New York-Denver circuit.

The phantom circuit produced in this manner is, however, not loaded. It is, of course, desirable to load the phantom circuit in order to obtain the benefits of improved transmission on this circuit also. To do this another loading coil was devised, the windings of which were so arranged that they would introduce inductance in the phantom circuit without affecting the side circuits in the physical circuits.

An important piece of work which it was necessary to carry on in parallel with the work dealing with the wire plant, was the development of a satisfactory cord circuit to be used with these very efficient loaded lines. Very successful results have been obtained in this direction. The losses with the old cord circuits were equivalent to making the line from New York to Denver 300 miles longer than with the present arrangement.

Another series of problems arose from the fact that we have not now and could not for many years expect to have traffic sufficient to justify three or even one through circuit from New York to Denver. Plans were worked out by which one or both of the physical circuits could be cut and made available for way connections without interfering with the use of the phantom on a through connection. Such arrangements are used at several points along the circuit. At other points the physical circuits, and also the phantom, are terminated and are available for connection to any other circuits in the usual manner.

Each of the various functions which we have caused these four wires to perform by the arrangements described above have been obtained in such a manner that no one of them substantially interferes with the others. The maintenance of the circuits, however, particularly of the phantom is not an easy proposition, and requires considerable skill on the part of those responsible for it.

THE BOSTON-WASHINGTON CABLE.[2]—The interesting feature of this cable, from an engineering standpoint, is that it is so constructed that practically all of the circuits in it may be phantomed and so that these phantom circuits as well as the side circuits of which they are made up can be loaded.

The loading problem on these cable circuits does not differ substantially from the problem of loading aerial phantom circuits which has already been described. The difficult work in connection with the design and construction of the cable was to have the circuits sufficiently well balanced so that they could be loaded and phantomed without bringing in objectionable crosstalk.

The make-up of this cable is shown by Fig. 3. In the middle of the cable there are 14 pairs of No. 10 B & S. gage conductors. Outside of these there are 36 pairs of No. 13 conductors. In the spaces between the No. 13 conductors and the No. 10 conductors, six pairs of No. 13 conductors have been put in because there was space for them. At the outside of the cable 18 pairs of No. 13 conductors have been placed because there was room for them.

All of the No. 10 gage pairs and the No. 13 pairs, except the six put in between the 10's, are arranged so that they can be phantomed. That is to say, they are arranged in what we call a "quad formation." Each of these quads is built up by taking two twisted pairs and twisting them together, giving due attention to the length of twist employed on the pairs, and in twisting the pairs together.

By this construction an arrangement is obtained which can be phantomed, providing certain necessary balances of capacity exist. For example, it is important that

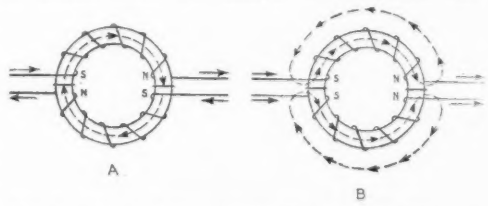


Fig. 2. Effect of Currents in Physical and Phantom Circuits, on Ordinary Loading Coils.

the capacity of each wire to the other side of the quad that is, the other pair, should be the same as the capacity of its mate. To attain this result, care must be exercised in manufacturing to see that the two wires going to make up the pair are twisted together symmetrically, that is, that there is no tendency for one wire of the pair to be straight or nearly straight, and for the other wire to spiral around it. In the same way care must be exercised in twisting up the quad that the two pairs twist about each other evenly.

In connection with splicing up this cable, care must be exercised, not only to see that the wires are correctly jointed together, but at certain points tests are made to determine the capacity unbalance of the circuits in two directions, and at these splices to so associate the wires and pairs as to have these unbalances in opposite di

*Abstract of a paper before the New York Telephone Society, April 18, 1911.

†Engineer of Plant, American Telephone & Telegraph Co., 15 Dey St., New York City.

[1]The theory of Prof. Pupin's scheme for overcoming the attenuation and distorting effect of electrical capacity by the insertion at calculated intervals, "loading" inductance coils, is described in Engineering News, Aug. 23, 1900. By "side circuit here is meant that familiar metallic circuit formed by two wires; by "phantom" circuit is meant the additional electrical circuit secured by using one wire of each pair in parallel) from each of two physical circuits. For the use of all three circuits for telephone purposes.—Ed.]

[2]See the article in this issue on the Washington-Wilmington Conduit for the reasons which led to the Boston-Washington Cable project.—Ed.]

rections, that is, so that they will tend to neutralize each other.

These precautions are necessary because the transmission efficiency of the cable is so great that crosstalk taking place at a considerable distance from either of the stations at the ends of the cable would be much more audible than in circuits of lower transmission efficiency.

I have already mentioned that the loading coils themselves are of the same general type as those used for loading aerial phantoms and the side circuits of phantoms. It is necessary to make those for the No. 10 circuits almost as big as those for open-wire circuits, to reduce the losses in the coils to a sufficiently small amount. The coils are spaced at intervals of about 1.4 miles, the side circuit coils and phantom coils being placed at the same point. This spacing is determined by the capacity of the conductors, the side circuits having a mutual capacity of about 0.070 microfarads per mile and the phantom having a mutual capacity of about 0.1 microfarads per mile.

The transmission efficiency of these circuits is interesting. While a sufficient amount of this cable has not as yet been manufactured to permit of actual transmission tests on it, so great is our confidence in formulas for computing these efficiencies, which have been developed as a result of our studies and experiments, that we are satisfied that the results predicted will be obtained.

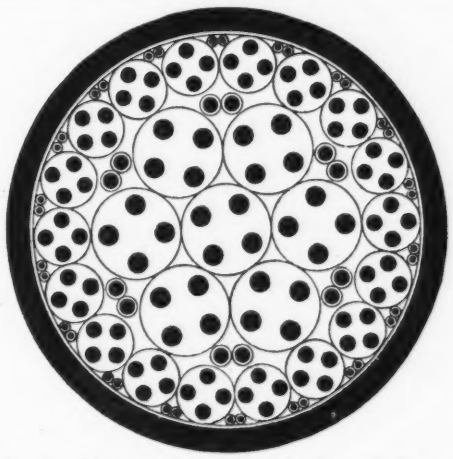


Fig. 3. Diagrammatic Cross Section of Boston-Washington Cable. (Full Size.)

The manufacture of about 150 miles of this cable at a cost, including loading, of about $1,000,000, has been recommended with complete confidence in regard to the results.

The distance from New York to Washington is 235 miles. The most efficient circuits is this cable will be the No. 10 phantoms. These will have a transmission efficiency equivalent to only 13 miles of standard cable. That is, they are nearly twenty times as good as standard cable and decidedly better than unloaded aerial No. 12's. The physical No. 10 circuits will have a transmission efficiency between New York and Washington of 16 miles of standard cable. The phantomed 13's will be equivalent to 21½ miles of standard cable and the physical circuits of No. 13 wire will be equivalent to 28½ miles.

These last circuits would not give good service from all subscribers in Manhattan to all subscribers in Washington. They will, however, be very useful from New York to Philadelphia, Wilmington and even Baltimore, and for other combinations such as Philadelphia and Washington.

Between Boston and Washington the only circuits that can be counted on for commercial service will be the phantomed No. 10's. These will give a transmission efficiency between test boards of 26 miles. This will be sufficient to insure the service in case the open wire lines are down, although it is not expected that they will have to be used in this way, because it is not likely that there will be so many breaks in the lines that the cable would have to be used at any time all the way from Boston to Washington. All open-wire lines are not likely to be down at the same time both north and south of New York City. The cable intersects the open-wire lines at numerous points between these two places so that patches can be made at short intervals.

THE COST OF ELECTRIC POWER, as developed in the isolated plant at the Massachusetts State House, has been found by Gov. E. N. Foss to be $220 per HP. per year. The plant was investigated by an engineer employed by the Governor, and he reported that such a plant, running 24 hours a day, ought to develop power for $85 per HP. per year. The cause was attributed to inefficiency and unbusinesslike methods. It was found, for instance, that the average amount of coal fired per man per 8-hour shift is 2.5 tons, compared with 5 tons in ordinary practice.

Apparatus for Applying Chemicals to Water Flowing in Pipes Under Pressure.

The modern tendency toward the use of hypochlorite and other disinfectants in the purification of water-supplies for drinking purposes has brought up the question of the most suitable means of applying these chemicals to the water. Perhaps the most obvious plan, and one which is largely used, is to introduce the chemical into the suction pipe or suction well of the pumps, but this is not entirely satisfactory. The chemical solution is liable to hasten the deterioration of the pump valves, and due to considerable momentary variations in the rate of flow, the solution cannot be applied in this way in very definite proportions.

To avoid contact with the pump valves, the solution can be added after the water has left the pumps; but the introduction of a definite proportion of some chemical solution into water flowing in a pipe under pressure is not an easy matter. The solution can be fed into the main readily enough by subjecting it to a pressure slightly exceeding the water pressure at the point where the feed pipe is attached, and the amount of solution introduced during any interval of time will depend on the difference between the feed pressure and the pressure in the main. The trouble is that the rate of flow through the main continually changes, so that the requirements are not met by simply maintaining the feed pressure at a definite amount above that in the main. The pressure difference could be adjusted to give the right mixture at the average rate of flow; but with diminishing flow through the main the water would be over-dosed, and under-dosed when the flow increased above the average.

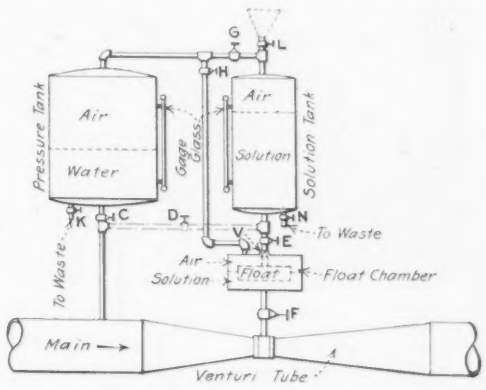
The problem has been met by the Simplex Valve & Meter Co., of 112 North Broad St., Philadelphia, Pa., by utilizing the well-known relationship betwen pressure drop and rate of flow in a Venturi tube. The feed pipe is connected into the throat of a Venturi tube in the main, and by means of suitable connections the supply of solution is subjected to the pressure in the main just above the Venturi tube. Thus the effective pressure difference forcing the solution through the feed pipe is always proportional to the existing rate of flow through the main.

The ingenious arrangement of the apparatus is shown diagrammatically in the accompanying illustration. The chief elements are the pressure tank, the solution tank and the float chamber. Solution is admitted to the float chamber from the solution tank through a needle valve V. This valve is controlled by a float which keeps the solution in the chamber at a constant level. The pipes shown by solid lines in the diagram are the only ones in use when the apparatus is feeding solution into the main. A pipe from the main just above the Venturi tube opens into the bottom of the pressure tank. Water rises in this pipe and compresses the air above it in the pressure tank until the pressure in the main is balanced. A pipe from the top of the pressure tank communicates with the upper end of the solution tank, and a branch from this same pipe opens into the float chamber. In this way, the same air pressure as exists in the pressure tank is made to act on the contents of the solution tank and the float chamber.

The proportion of solution fed into the water in the main is regulated by adjusting the gate valve F. By observing the rate at which the solution level drops in the gage glass on the solution tank and comparing it with the volume of water flowing in a given time through the Venturi tube, the proportion of solution being added can be definitely determined. When the valve F is once set at the correct opening, the solution will continue to flow at the desired ratio of grains per gallon regardless of variations in the amount of water flowing. This is because the pressure drop through the valve F is always practically the same as the difference in head at the full and contracted sections of the Venturi tube, which varies in direct proportion to the volume of water passing through.

The pressure on the solution in the float chamber will be slightly less than that in the main, due to the head of water in the pressure tank. This pressure difference would be of no consequence so long as it were constant, since it would be compensated in the adjustment of the feed valve F. As a matter of fact, however, the water in the pressure tank will rise while the solution is being drawn off from the solution tank. The amount of this rise will depend on the ratio between the diameter of the pressure tank and the capacity of the solution tank. If the capacity of the solution tank be made, say, 130 gals., the rise of water can ordinarily be reduced to a fraction of one per cent of the total head on the main by making the pressure tank 4 or 5 ft. in diameter. The effect on the solution feed will then be negligible.

As the solution is drawn off from the solution tank, the water rises in the pressure tank until finally when all the solution has been drawn off an equivalent volume of water will have been admitted to the pressure tank. The solution tank will meantime have received the same volume of compressed air. This air can be returned to the pressure tank by closing valves C and E and opening valves D and K. This causes water



A Device for Adding Hypochlorite or Other Disinfectants to Water in Pipes Under Pressure.

(With high pressures, the float valve and chamber can be omitted.)

from the main to pass into the bottom of the solution tank and drive the air before it back into the pressure tank. The water in the pressure tank is driven out by the air and escapes through the drain valve K. The solution tank is next cut off from the main and from the pressure tank by closing valves G and D, and can then be emptied of water through the drain valve N. A fresh charge of solution is then poured in through the funnel shown by dotted lines, and everything is ready to begin feeding again as soon as the valves G, E and C are reopened.

In the actual design, the number of valves is reduced by using three-way cocks, and these are arranged side by side so that with a little practice the attendant can recharge the solution tank and restore its operation quickly and easily. The apparatus is built in slightly modified forms to suit different requirements. In some cases, for example, the float chamber can be omitted (when the pressure in the main is high), and if desirable the air can be replaced by some other gas or by a liquid whose specific gravity is less than that of water. Any other form of contracted pipe section can be substituted, if desired, for the Venturi tube; but it will probably be found convenient in most cases to install the dosing apparatus in connection with Venturi tubes used for metering the water-supply.

CAUSES OF SHIPWRECKS on the Atlantic and Gulf coasts are tabulated in the reports of the U. S. Life Saving Service. In the year 1909, 501 vessels were reported lost or damaged, of which about 45% were steamers, 34% schooners, 9% barges, 5% ferryboats and 7% miscellaneous. By far the most frequent cause of disaster was collision with other vessels, 44% of the total number of accidents being attributed to this cause. Next in order came gales and hurricanes, 11.5%; fire, 10.5%; collision with bridges, piers and rocks, 6.6%; fog, 6.4%; and miscellaneous causes, chief among which were officers' or crews' errors and leaks, 21%.

Block Signals With Automatic Stops on the Interurban Electric Lines of the Washington Water Power Co.

Railway officials, both steam and electric, perhaps have been more subjected recently than for any time past to demands for the use on their lines of some mechanism which shall automatically apply the brakes on any train which shall run past a warning signal. As pointed out at various times and quite recently (Eng. News, Dec. 20, 1910, p. 726), devices to secure this very desirable end are not new, and in one form or another have accompanied the development of railway signaling almost from its beginning. A recent article by M. Hoogan (Eng. News, Dec. 20, 1910, p. 706), outlined the findings of a German commission which made a study of the various available schemes to prevent railway collisions. Here were shown studies covering three years which failed to discover an automatic stop which would, on the whole, increase safety of operation. As we have pointed out before, there are various limitations to the service which an apparently perfect stop can perform. For instance, in most cases a stop must be advanced toward an approaching train so as to stop it close by the danger signal. This means that the engine driver cannot run up to the signal itself when it is set against him, and this involves a stretch of dead track from 1,000 to 1,500 ft. long. Such automatic stops generally apply the emergency brake, which application is undesirable if made often. Therefore, it is evident that each device needs to be considered in connection with each proposed installation in specific cases, and general conclusions of safety to be secured are not to be drawn alone from the consideration of any desirable features which a stop may possess, viewed as a piece of mechanism.

Such warnings as have been given from time to time in various quarters as to the lack of wisdom which must be back of insistence that high-speed trains should always use automatic stops in connection with warning signals, do not prevent the study of interesting installations. One such case where the local objections to the use of an automatic stop seem to have been eliminated is that of the interurban electric lines of the Washington Water Power Co., of Spokane. This is reported (Annual Report of the Block Signal and Train Control Board to the Interstate Commerce Commission, November, 1910) to be the first installation in the country of a permanent automatic stop on a surface railway, if exception is made of the Harrington device which has been given two years' experimental service on the Erie R. R. in New York. It is also said to be the first case in the country where all motor cars are equipped with a device which applies the brakes on running past a "stop" signal.

On account of the long period of winter weather met with in this section, a track trip or a valve on top of the cars was considered useless because of liability of being frozen and inoperative. Therefore, a glass tube has been arranged in a fitting so as to project above the roof of the car, as shown in Fig. 1. The glass tube is broken against a barrier which drops in unison with the semaphore arm. The tube is connected to the control of the air-brake system by entirely independent piping, so that it cannot be interfered with. The idea of using an overhead pivoted arm operated with or by the semaphore to break a glass tube or bottle on the car is not new in itself. Of such, the Block Signal and Train Control Board writes in its 1910 Report, p. 237:

* * * while its application is likely to be limited, its construction is simple, and with apparatus well maintained its use should tend to increase materially the safety of operation on a road where the operating conditions are such that it can be used.

Fig. 1. Set at "Stop."

Fig. 2. Set at "Proceed."

FIGS. 1 AND 2. HOME SIGNAL AND BARRIER. WASHINGTON WATER POWER CO. LINES.

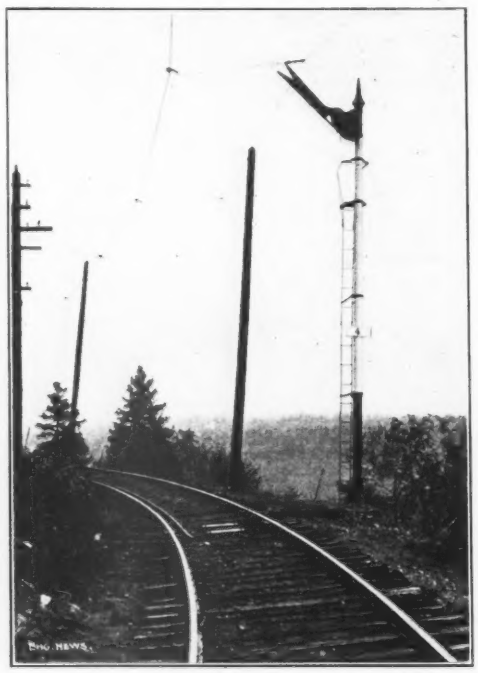


Fig. 3. Distant Signal (No Barrier) of Automatic Block System for High-Speed Electric Lines.

The designers claim that after much experimental work all the objectionable features of automatic stops have been eliminated for this particular service and that a proper system of overlaps has eliminated all chance of two trains coming together. The system is probably much more expensive than usually seen on an electric interurban line with any signal system at all, but the protection secured in this case is considered by the operating company to justify the expense. A single pair of car wheels anywhere on the main line within a given block sets the "stop" and "caution" signals and holds them down until the responsible wheels have cleared that block, either by going onto a siding or by leaving the block itself for another. The same warnings are secured by a broken or removed rail, or if the insulation of the special track joints disappears. Moreover, the throwing of a switch within the block sets the danger signals of the block and no train can enter without complete warning. The circuit of all signals governing over a switch are carried through a circuit controller attached to and operated by the switch points and arranged so that the signal circuits are opened as soon as these points are opened a sufficient distance, usually from ¼-in. to ⅜-in., to make high-speed facing dangerous. This action of the switch box takes place whether the opening of the points is deliberate or accidental.

The installation consists of 29 automatic semaphores distributed variously along the 29 miles of single track line connecting Spokane, Cheney and Medical Lake, as shown in Fig. 5.

Direct current for car power is obtained at 600 volts from an overhead wire, with both rails used as a track return. Both rails are also used as part of the alternating-current signal circuits. This joint use is secured by dividing the track into sections, for signal control, by means of insulated rail joints and by providing reactance bonds connected around the insulating joints. These permit the flow of direct current but practically prevent the flow of alternating current signal current from one section to another. The alternating-current for track circuits varies from 1.5 to 8 volts, according to the length of sections, which varies from 175 to 15,150 ft.

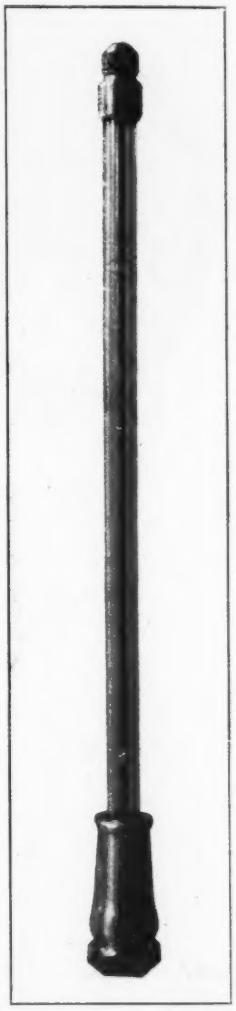


Fig. 4. Breakable Glass Fitting for Automatic Train Stops.

The signal mechanisms are all electrically operated and these, together with all relays, bonds, signal lamps, etc., are supplied with power taken from a line installed for this supply service.

In Fig. 5 is shown a layout of the overlaps by which the control of all signals by a train is carried to a point beyond the next opposing signal, so as to make it impossible for two trains to meet, one will receive a "stop" signal (or will be actually stopped), at least a full block from the other. When a train enters a block not only does the signal at the entrance and the signal controlling the movement in the opposite direction at the exit end both assume the stop position, but the next home signal in the rear and

any intermediate distant signal remains in the stop position until the train has passed out of the next block ahead of that which it is entering or, if the overlap control is less than a full block, that portion of the second block ahead which is designed for the overlap control. Thus a train passing Signal 23 and moving toward Signal 25 sets Signals 23 and 30 at "stop" and holds Signals 21 and 19 in the rear at stop. Signal 19 does not clear until the train has passed the point of overlap control, which in this instance is (approximately) the transformer located at the center of the track section between Signals 23 and 30. Signals 23 and 21 will not clear until the train has passed the transformer at the center of the track circuit between Signals 25 and 32. With center-fed sections, a relay is provided at each end of the section and the overlap control of signals in the rear is taken through only one of these two. The train must be past the feed point a short distance before the drop along the rails between the transformer and the short-circuiting wheels is great enough to permit enough current to flow toward the entering end of the block to pick up the relay there. This is not shown on Fig. 6, for the sake of simplicity.

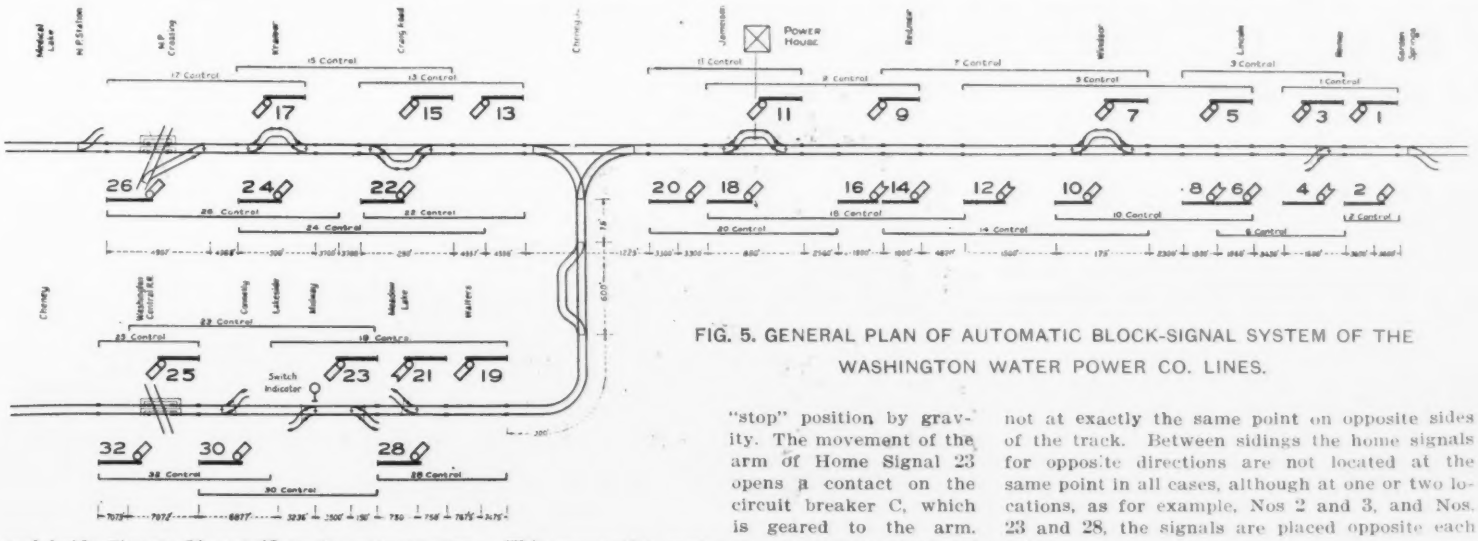


FIG. 5. GENERAL PLAN OF AUTOMATIC BLOCK-SIGNAL SYSTEM OF THE WASHINGTON WATER POWER CO. LINES.

The extent of the track-circuit control for each signal is clearly indicated in Fig. 6, it being understood in studying this diagram (1) that every signal assumes the stop position as soon as a train enters that portion of the track by which it is governed; (2) that the signal remains in the stop position as long as the car is in that length of track; (3) that it is immaterial as to which direction the train is moving when it enters the section of track by which the signal is governed and (4) that all opposing signals within the limits of control of a given signal are set or held at "stop" so long as the train is on that portion of the track which governs both the controlling signal and the opposing signal.

The details of signal operation may be seen from a study of Fig. 6. If a car has just passed "stop" position by gravity. The movement of the arm of Home Signal 23 opens a contact on the circuit breaker C, which is geared to the arm. This opens the motor circuit of Distant Signal 21, which is from the transformer, Ts, through the circuit breaker, C, the wire, X, the contact on the relay, 2, the switchbox, the control wire, 21, and the motor, to the common wire. Distant Signal 21 therefore remains in the caution position, while Home Signal 23 is at "stop." The opening of the contact, S, on the relay, 1, breaks the motor circuit of Signal 19, which is from the transformer, Ts, through the contact, S, of the relay, 1, the contact on the relay, 2, the switchbox, the wire, Y, the contact on the relay, 3, the control wire, 19, the contact on the relay, 4, and the signal motor to the common wire.

Signal 19 would have been set at "stop" by the opening of the contact on the relay, 4, when the car passed Signal 19, and it would have been held successively at stop by the opening of the contacts on the relay, 3, and the relay, 2, as the car had advanced to Signal 23. The opening of the contact on the relay, 2, when the car passed Distant Signal 21, would set the latter at "caution," and the opening of the circuit breaker C on Signal 23 would hold this Distant Signal 21 in the caution position after the car had passed out of the track section by which Signal 21 is directly governed and until the car had passed beyond the controlling point of Signal 23.

As soon as the car passes out of the block, the relay, 1, picks up and closes the contacts, S and M. This restores the motor circuit of Signal 19, causing the arm to move to "proceed"; as soon as Home Signal 23 closes the contact, C, on its circuit breaker, Distant Signal 21 also clears. Signal 30, which is the opposing signal at the exit end of the block, is also controlled by a contact (not shown) on the relay, 1, and it is evident, therefore, that the entrance of the car into the block would also cause Signal 30 to assume the stop position against opposing cars.

It will be seen that at each through siding are placed two home signals controlling movements in opposite directions. In general, these signals are placed close to the entrance switches and not at exactly the same point on opposite sides of the track. Between sidings the home signals for opposite directions are not located at the same point in all cases, although at one or two locations, as for example, Nos 2 and 3, and Nos. 23 and 28, the signals are placed opposite each other.

The semaphore signals are of a single arm, three-position, upper quadrant, railway type, but differ from the standard arrangement in having (1) only 45° travel of arm; (2) the auxiliary barrier, and (3) the semaphore arm displayed to the left of the supporting post. The first and third changes were necessary for a simple arrangement of the barrier. The third change was also made to give the motorman a clearer view of the signal than could be obtained otherwise, on account of the interference of the many poles along the right of way required to support the trolley wire.

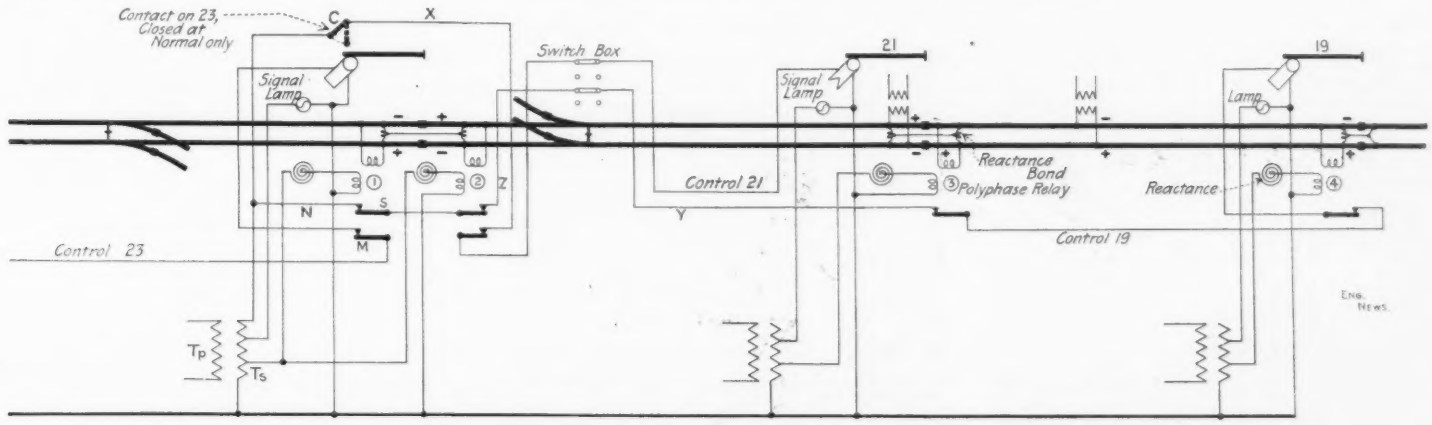


FIG. 6. TYPICAL ARRANGEMENTS OF CIRCUITS, ALTERNATING-CURRENT, AUTOMATIC-BLOCK, SIGNAL SYSTEM.

The semaphore arm is moved by a series-wound alternating-current commutator motor designed for high starting torque and low current consumption. The low current may be judged from the fact that the motor receives its supply over a circuit of No 10 copper wire from one block in advance, a distance varying from 175 to 15,150 ft., without use of a line relay. The total maximum line resistance, through which any one of these signal motors here operates, is 74 ohms. The armature shaft carries a centrifugal governor to control the speed and to prevent over travel. The motor is geared to the semaphore shaft and normally holds the arm in the "clear" position; that is, current is on the motor normally, but the current is limited to the necessary minimum by a reactance coil which is slipped into the motor circuit by the circuit-breaker at the end of the clearing movement. The semaphore arm and the auxiliary barrier return to "stop" position by gravity. During the back travel of the motor it is short circuited, by the circuit breaker, to

brake the motion. This scheme of directly gearing the motor to the semaphore shaft removes the necessity of dash-pots, etc.

The circuit-breaker has already been mentioned in connection with Fig. 6. It is complete in itself and is connected directly to the semaphore shaft by segmental gears. It carries contacts for the control of up to 12 circuits, including the local control of the signals. This control of so many circuits more than shown in the discussion of Fig. 6, is in part necessary for the long overlaps seen in Fig. 5. It is evident that the discussion of Fig. 6 does not show the complete connections for every signal on the line.

The relays spoken of above are essentially two-phase induction motors with limited travel. The field coil of one phase is energized from a transformer at the relay and the other from the track circuit, as shown in Fig. 6. This permits the greater supply of energy to come from the local source with small transmission losses. The relays are able to operate with a slight amount of energy from the track circuits, which permits of single sections as long as the 15,150 ft. mentioned. Such a length of continuous track circuit is claimed to be unapproached in any railway signaling system heretofore installed. The general appearance of the relays is shown by Figs. 8 and 9. The rotor motion is transmitted to the contacts by a trundle pinion engaging with a segmental gear, the latter connected to the contact bar by a crank. The contacts are made to rub for 1-16-in. of final travel to ensure constant cleaning. Ball bearings are used in all rotating parts.

From the discussion of Fig. 6, it is seen that the contacts are opened by a short-circuiting of the track circuit by the car wheels. This deprives the relay motor of torque and causes the contacts to be opened, the necessary back travel of the rotor being obtained by gravity, a weight being provided on the sector between rotor and contact bar.

Oil-cooled transformers of common appearance are used to supply the various track and signal circuits at each signal and track-feed location, with the proper low-voltage currents. Current is taken from the Jameison substation, as shown diagrammatically in Fig. 5, approximately at the center of the lines and distributed at 2,200 volts. Lightning arresters are installed in the primary circuit about each half mile and to further prevent the entrance of lightning on the low-voltage lines, grounded copper plates are placed between the primary and secondary coils of the transformers. There are independent secondary windings supplying the track, lighting and relay circuits and the signal motors. The track-supply secondaries are provided with voltage taps for a range of from 1.5 to 8 volts; the signal-circuit secondaries give 220 volts, with 55-volt taps for the signal lamps and 28-volt taps for the relays, as shown in Fig. 6. The barrier arms are attached to the semaphore arms and worked by the latter, though counterbalanced for ease in operation. These barriers are made of two pieces of pipe slipped together and bolted so that they cannot be taken apart without a wrench.

All motor cars are provided with one of the glass fittings shown in Fig. 2. The cars are built for single-end operation so that only the forward right-hand corner of the roof carries one of these fittings. Should the motorman overrun a signal and break a tube, he puts a cap over the pipe until he reaches the next station. Should he pass a station without renewing the tube, he is immediately discharged. This method saves checking up spare fittings at the end of each run and give immediate reports. Since the system went into operation, more than six months ago, there has not been a tube broken by a motorman's running through a block.

There is a lock on the semaphore pole by which the conductor can raise the arm to pass the barrier in case the signals go to "stop" without normal cause, as in the case of interruption of signal current or a disabled signal or relay. The semaphore arm and barrier must be dropped back to the "stop" position before the key can be taken from the lock. Conductors are allowed thus to "lock through" a block only on orders from the train dispatcher, or, as later shown, in order to save time at a meeting place. Each signal pole is provided with a telephone jack, and each motor car carries a portable telephone set so that the crews can always get into easy communication with the dispatcher for orders. Keys to the signal locks are all numbered and are charged to the holders.

As noted before several times, these are single-track lines, so that regular meeting points have to be arranged in accordance with the running schedule. The sidings are shown in Fig. 5. As an instance of the operation at such meeting points, imagine a westbound train passing Signal 5 (Fig. 5), and scheduled to pass an eastbound train approaching Signal 12. In passing Signal 5 the westbound train sets Distant Signal 12 at "caution" and Signal 10 at "stop." The eastbound car on arriving at Signal 12, set at "caution," understands that the westbound train has passed Signal 5. General instructions have been given that the train first arriving at the meeting point takes the siding so that if the westbound train reached a turnout first it would lock by Signal 7 and go onto the siding to wait until the eastbound came through on the main line. When Signal 7 is passed by the westbound train, Signals 14, 12 and 10 would all be set against the eastbound car, but on taking the siding (insulated from the main line signal circuits) all signals before the eastbound train would be cleared. On the other hand, if the eastbound train reaches Signal 10 (at "stop") before the westbound reaches Signal 7, the crew of the former would "lock by" Signal 10 and proceed to the turnout. The presence of the train in this block would set Signal 7 at "stop," but on taking the siding that signal would be cleared up for straight running on the main line westward. This arrangement has been found to work well in practice, the regular crews helping each other in the way shown so that no time is lost.

By test, it was found that a two-car train (motor and trailer) which ran through a danger signal at 40 miles per hour was stopped in a little more than 300 ft. A semi-service application of the brakes has been employed with a pressure of from 35 to 40 lbs. on the glass tube. With the semi-service application there is no jamming of the brakes and slipping of the wheels.

The breakable fitting was designed by Mr. R. A. Wilson, General Superintendent of Railways, Washington Water Power Co., Spokane. The addition of tube, barrier, etc., to the regular brake and signal apparatus was arranged by Mr. Willson and Mr. A. L. Wright, of Wright & Bell, Spokane. All of the apparatus described above was built by the General Railway Signal Co., of Rochester, N. Y. For the information here presented we are indebted to all of these parties.

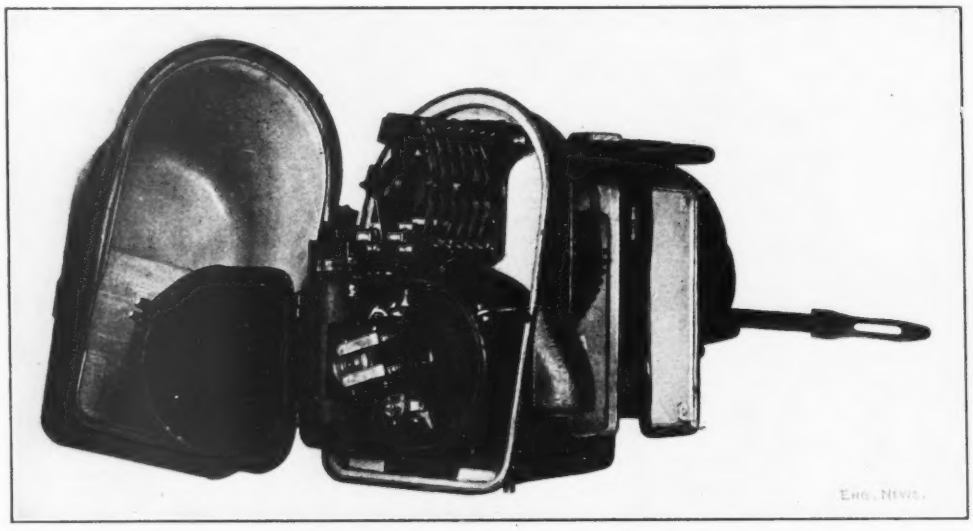


FIG. 7. SEMAPHORE MOTOR AND CIRCUIT-BREAKER MECHANISM.

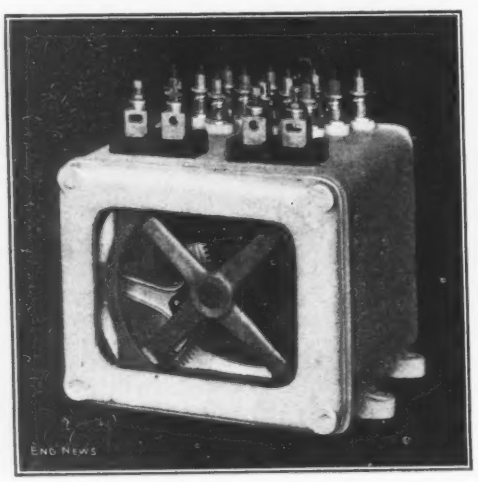


Fig. 8. Motor End.

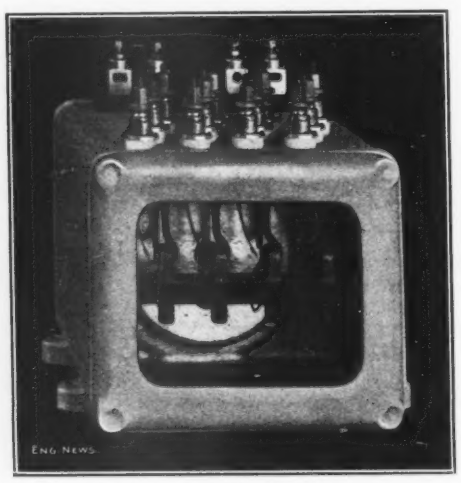


Fig. 9. Contactor End.

FIGS. 8 AND 9. ALTERNATING-CURRENT, BLOCK-SIGNAL RELAY.

WATER STORAGE ON STATE LANDS in the Adirondacks is authorized by a constitutional amendment which passed the New York Legislature last year, and which, if passed again this year, will be submitted to popular vote at the November election in 1911. The amendment applies to Sec. 7, Art. 7, of the Constitution, and authorizes the Legislature to pass general laws for the construction and maintenance of reservoirs under state control in the forest preserve "whenever the storage of water is necessary for municipal water-supply, for the canals of the state or to regulate the flow of streams." Safeguards are thrown around the exercise of this power. The constitutional amendment mentioned is a sweeping provision to the effect that all the New York Forest Reserve shall be kept forever in its natural state, thus prohibiting not only the use of any portion of the land for water storage but also even the most elementary forestry work.

Diesel Engines for Sea-Going Vessels.*

By J. T. MILTON,† M. Inst. C. E.

The possibility of employing internal-combustion engines for the propulsion of large vessels has recently been prominently before those interested in shipping, and, as it had been decided to fit several vessels intended to be classed in Lloyd's Register with these engines, the Committee of that society determined to obtain as much information as possible in regard to their construction and their suitability for the purpose. As the Diesel engine in some of its forms appeared to be making the most progress, they asked for, and obtained, the co-operation of those firms on the Continent who had given special attention to this form of engine for marine work, and visits were made by the Chief Engineer Surveyor and other officers of the society to each of the firms in question, and much useful information was obtained. The firms were:—Messrs. Burmeister and Wain, of Copenhagen; the Nederlandsche Fabriek van Werktuig en Spoorweg Materieel, of Amsterdam; Messrs. Carels Freres, of Ghent; the Maschinenfabrik Augsburg Nurnberg, of Nurnberg; Messrs. Sulzer Brothers, of Winterthur; Societe John Cockerill, of Seraing; and Messrs. Schneider et Cie., of Le Creusot, each of which, besides having considerable experience in the design and manufacture of internal-combustion engines, had either completed, or had in course of construction, some Diesel engines for marine purposes. The British Diesel Engine Co. was consulted, and a visit was paid to Dr. Diesel, with the same object in view. This gentleman and the principals of the above-mentioned firms courteously and freely gave full information upon every point upon which their previous work had given them experience.

Since then several British firms have decided to make Diesel marine engines, and as numerous inquiries are being constantly made by those interested in the subject, the present paper has been prepared. It is hoped that the information contained in it, and that brought out in the discussion which will follow, will be of service to shipowners, engineers and shipbuilders, and will not be without interest to underwriters also.

It need hardly be pointed out that the inducement to forsake the tried and trustworthy servant, the steam-engine, for ordinary sea-going vessels, will be mainly, if not solely, the question of fuel economy; but this point, important though it is, would not of itself warrant a change to a new type of engine unless equal certainty of continuous efficiency on the voyages to be undertaken was provided—that is, as little risk of accidents to machinery, and as great facility for using temporary expedients for reaching port in case of breakdown of part of the machinery. There must also be a prospect of a reasonable cost of upkeep. To each of these points some attention will be given in this paper.

Fuel.

It is evident that, apart from the question of the relative cost and facilities for obtaining supplies of oil fuel and coal, an internal-combustion engine using oil possesses many advantages for marine work over one using gas made from coal. Even for land installations the same thing may be said, inasmuch as with oil the comparatively bulky gas-producers and scrubbers are not required. There is no trouble with gas in the cylinders, and there should be none with tar on valve-faces, etc. Even as fuel for marine steam-boilers the advantages of oil over coal are very great. Weight for weight it has at least 50% higher evaporative efficiency. It occupies less space per ton than coal. It can be carried in double bottoms and other spaces unsuitable for coal or cargo. It requires no trimming, and lessens the number of stokers necesary. Owing to the higher temperature produced and more perfect combustion obtainable, more power can be realized by its use from the same size of boiler. There is greater regularity of power than with coal, owing to there being no fire cleaning necessary. It can be quickly pumped from the stores into the bunkers, and the labor and dirt of coaling ships are avoided. Yet, with all these advantages, oil fuel for ships' boilers is very little used as compared with coal. Leaving war vessels out of account, oil fuel is only used on shipboard in those places where the natural advantages render its use more economical than coal, and by vessels which trade regularly to ports where supplies can be obtained. For the ordinary cargo steamer which has to seek employment all over the globe coal is still the necessary fuel.

It is said that unlimited quantities of oil are known to exist, well distributed throughout the tropical and temperate regions of the world, and that, given a regular and steady demand for it, commercial enterprise will place ample supplies upon the market. Undoubtedly, for many years most of the oil raised was for the supply of the refined products, gasoline, lamp-oil, and to a less extent lubricating oil; the residuum, after these had been distilled from the crude oil, being a by-product which had either to be thrown away or used as fuel. In these conditions, with a comparatively limited supply of residuum, its price would naturally be determined not by the cost of raising oil, but by the value of the coal with which it had to compete. The market for refined oils, although large, is not unlimited, and it is thought by some that they are at present over-produced. The cost of distillation is a very considerable factor. Considerations of safety render it necessary to use in ships' boiler furnaces only fuel oils having a comparatively high flash-point. This practically shuts out from marine boiler use those crude oils which do not contain sufficient of the lighter hydro-carbons to make it profitable to distill them, but which contain sufficient to give them a comparatively low flash-point. If the oils are to be used in closed cylinders instead of in ordinary boiler furnaces, there is not the same necessity for demanding a high flash-point. Experience has shown that even the extremely volatile "gasoline" can be safely carried in bulk on board ship.

From the above it may be considered that, if internal-combustion engines of the oil-burning type become common in sea-going vessels, crude oil, rather than the residues from distillation, will form the major portion of the fuel employed, raised, perhaps, in places where it may be profitable to distill some portion, but it will also be profitable to employ crude oils that are not suitable for distilling.

In regard to this matter it may be well to state here that it is claimed for the Diesel engine that any oil can be used in it which will burn completely, leaving no residue. If this is so, the different qualities of oil must require special experience to know how to adjust the fuel valve to spray them properly, so as to obtain a suitable combustion that will, on the one hand, consume them sufficiently slowly to prevent an undue rise of pressure, such as occurs in gas and gasoline engines, and, on the other hand, will permit of their total combustion in the engine. There have, however, been objections taken to this view. Mr. Paul Rieppel, of the Maschinenfabrik Augsburg Nurnberg, of Nurnberg, who has had much experience with internal-combustion engines, has made some elaborate investigations on this point, and, after experiments with many kinds of oils, he has come to the following conclusions:

The various hydrocarbon oils, which occur either as natural products or as the result of distillation either of brown coal, ordinary coal, or crude oils, may be divided into two classes, which differ very much in their behavior when raised to such a high temperature. Those of one class, when raised to such a temperature as is obtained by the compression in Diesel engines, readily decompose into free hydrogen and heavier hydrocarbons; those of the other class at first only vaporize, or partially vaporize, and require much higher temperatures than that due to the compression for their decomposition. In those of the first-class the hydrogen, because of its easy ignition, burns first, and the resulting heat enables the remainder of the hydrocarbons to become completely burnt, the total combustion taking an appreciable, though small, amount of time. In the second, a very high temperature is required to initiate combustion, which, when commenced, approximates to an explosion, owing to part of the oil, having been made gaseous, becoming mixed with the compressed air, and so constituting an explosive mixture. The latter oils, therefore, may be either not properly consumed, or they may be burned with explosive violence.

It should be mentioned that Mr. Rieppel states that even these oils can be used in the Diesel engine by means of special alterations in the design, but it would not appear that they could be used in an engine adjusted for the more suitable oils. In general the oils which are not suitable appear to be the result of distillation of ordinary coal, so that this matter is of more importance to the users of land engines, whilst the oils made from brown coal or from natural crude oils appear to be well suited for Diesel engines.

There is, however, another point which requires attention. Some of the crude oils, and therefore all the residues from their distillation, contain combined sulphur. Some oils are credited with containing as much as 2%. This element, especially at high temperatures, has an affinity for copper, and it has been found that where oil containing sulphur has been used the valves and fittings coming into contact with the oil must not be made of copper or copper alloys. Fortunately cast-iron appears to resist the action of the sulphur, and valves, etc., made of this material have stood well where brass valves have failed. This point shows also the advisability of making oil-fuel pipes of steel or iron, instead of using copper, unless it is certain that the fuel supply will not contain sulphur.

Whilst dealing with the question of the quality of oil required, it may be advisable to state that extended experience has shown that the requirements of Lloyd's Rules for oil-fuel bunkers, etc., have proved their sufficiency for safely dealing with heavy oils suitable for boiler fuel having a flash-point of not less than 150° F. Such oils have been through refineries, and all light hydrocarbons have been distilled from them. Any gas arising from them at even tropical temperature must be very small in quantity and entirely negligible. Provision is made for dealing with any possible leakage from any of the oil-fuel compartments, and fore-and-aft peak tanks and double bottoms under cargo holds, may be safely used for the fuel. If, however, oils are to be used for engine fuel which have a low flash-point, or which give off a perceptible amount of gas, it will be undesirable to carry them in double bottoms under cargo holds, or in spaces from which a leakage would permit of vapors or gas penetrating into cargo holds or other closed spaces where they would be a source of danger.

It must be remembered in this connection that some of the hydrocarbons, creosote, for instance, have a most objectionable and penetrating odor, capable of contaminating and spoiling many kinds of fine cargoes. However, as gasoline can be safely carried in bulk, suitable provision can be made for any kind of oil to be carried without risk either to the vessel or her cargo.

It may be well to state here what is claimed for the Diesel engine in the way of consumption. In an ordinary steam engine, the power is generally reckoned as indicated horsepower. This is the work performed by the steam on the piston, and is the gross power obtained. It has to overcome the friction of the mechanism, work the slide-valves and the pumps, and only about 85% in round numbers is transmitted to the shaft.

In the Diesel engine the indicated horsepower has similarly to overcome the friction of the mechanism, it has to work the fuel-pump, the mechanism for actuating the valves, and to supply the compressed air necessary for injecting the fuel. In the two-stroke cycle also it has to work the scavenging pump. These take up more of the gross power than do the accessories in a steam engine, and hence a less proportion of the gross, or indicated power, is transmitted to the shaft than in a steam engine. For this reason the power of a Diesel engine is more usually expressed as its brake horsepower—that is, the power usefully exerted outside itself.

It is usually claimed that the oil consumption per brake horsepower per hour is 0.4-lb. when the engine is working at full power, and when working at somewhat lower powers the rate of consumption is not much increased. If one assumes that in a modern steam engine the consumption of coal is 1.25 lbs. per indicated horsepower per hour this corresponds to about 1.47 lbs. per brake horsepower, so that the weight of fuel to be carried for the same voyage in a vessel fitted with Diesel engines would be only 28% of that of the coal necessary with ordinary steam engines.

Construction and Operation.

We will now turn to the engine itself. Its principle of working is generally known. It is made in three forms for marine purposes—viz., as a four-stroke cycle single-acting engine, a two-stroke cycle single-acting engine, and a two-stroke cycle double-acting engine. An essential feature of these engines is that they require, besides their own cylinders and pistons, an auxiliary air-compressor capable of producing a pressure of about 700 lbs. per sq. in.

In the four-stroke cycle engine the cylinder-cover contains a fuel-valve, a compressed-air admission-valve, one or more ordinary air-admission valves, and one or more exhaust-valves. All these valves are actuated—that is, opened—by means of cams fixed to a cam-shaft, and are kept closed by powerful springs when the cams are out of action. The cam-shaft is driven by a two-to-one gear—that is, it makes only one revolution for two revolutions of the engine crank-shaft. Broadly speaking, the cams are so arranged that the air-admission valves are open during one whole down-stroke, and the exhaust-valves during one whole up-stroke, but actually a little "lead" is necessary. The cams for the fuel-valve and the compressed-air valve are so arranged that only one of these can be in operation at a time, so that when either is in use the other is entirely inoperative. In ordinary running, the fuel-valve is opened at the proper time when the piston is at the top of its travel, and is closed again when about one-tenth of the downward stroke has been made. The compressed-air valve is only used for starting purposes, and it is kept open for a longer period—say, for half or even more of the stroke—its range of opening being made to depend upon the number of cylinders used, so that when these valves are in gear there is no position of the engine in which there is not at least one of them open.

In starting the engines these valves are put into gear, and the fuel-valves are consequently put out of action. When the engine has made one or more complete cycles, the compressed-air valves are put out of gear, the fuel-valves commence their work, and the engine then continues its motion, working under "fuel" conditions. As the air-admission valve-gear is in full action during the starting operations, the full compression would have to be overcome in each cylinder in turn, if it were not for a special arrangement made to relieve part of the pressure in order to facilitate starting. This is put out of action when the fuel admission is put into gear.

*Abstract of a paper read before the Institution of Naval Architects, April 6, 1911, at London, Eng.

†Lloyd's Register, 71 Fenchurch St., E. C. London, Eng.

Commencing with a piston at the top of the cylinder, the four-stroke cycle is as follows:

First Down-Stroke.—The ordinary air-admission valve is opened during the whole stroke, and the cylinder becomes filled with atmospheric air at the ordinary atmospheric pressure.

Second Stroke.—The air-valve is closed, and the piston returns to the top of the cylinder, compressing the air which had been drawn in during the previous stroke. The clearance is so proportioned that in ordinary working at full speed the pressure becomes about 500 lbs. per sq. in. and the temperature is, at the same time, very much raised. The compression is not quite adiabatic, as the cold cylinder walls must abstract a little of the heat from the air. If it were truly adiabatic the temperature of the air would be raised from, say 60° F. to 1,000° F.

During this stroke a quantity of fuel has been pumped by the fuel-pump into an annular space round the fuel-valve. When the piston is at the top of the stroke, the fuel-valve is raised, and, at the same time, cold air from the air-compressor reservoir at a pressuse of 700 lbs. per sq. in. blows the fuel into the cylinder, which contains hot air, at a pressure of 500 lbs. per sq. in. The construction of the fuel-valve is such that the oil is pulverized or atomized—that is, it is divided up into a spray of very fine particles. These, upon coming into the very hot air in the cylinder, ignite, and the heat produced by the combustion increases the volume or the pressure of the air. When the adjustment of the valve is correct, the admission of the fuel and the combustion proceed at such a rate that they are almost completed during the time taken for the piston to travel one-tenth of its stroke, and during this period the pressure of 500 lbs. per sq. in. is maintained.

Third Stroke.—The third stroke of the cycle commences with the combustion of the fuel as mentioned above, after which, during the remainder of the stroke, the hot gases in the cylinder expand until the end of the stroke is reached.

Fourth Stroke.—The return of the piston constitutes the fourth stroke, and during this time the exhaust-valves are open, and the burnt gases are expelled from the cylinder. After this the cycle commences afresh.

In the two-stroke cycle single-acting engine, the cylinder covers are similarly fitted with fuel valves and compressed-air valves for starting purposes, but the ordinary air-inlet valves and exhaust valves are replaced by scavenge-air valves. All these valves are actuated by cams; the cam-shaft, however, in these engines rotates at the same speed as the main engine shaft.

The pistons are made somewhat deeper than the total length of stroke. At the lower end of the part of the cylinder barrel uncovered by the movement of the piston, there are numerous ports leading into the exhaust passage. These ports have a vertical dimension of about one-seventh of the stroke.

The two-stroke cycle is as follows:

First Stroke.—When the piston is at the bottom of the stroke the cylinder is full of pure air at atmospheric pressure, which air has just been admitted through the scavenge valve. During the up-stroke the air is compressed up to 500 lbs. per sq. in., precisely as in the compression stroke of the four-stroke cycle engine.

Second Stroke.—The second stroke commences at the top center by the admission of fuel sprayed in by compressed air, precisely as in the previously described engine, and the stroke proceeds in exactly the same way until the piston has traveled about six-sevenths of the stroke. At this point it commences to uncover the exhaust ports through the cylinder sides. So much of the hot gases escape through these ports as to reduce the pressure in the cylinder to about that of the atmosphere. The scavenge valves are then opened, and fresh air under pressure is admitted into the cylinder, blowing out the remainder of the burnt gases into the exhaust passages. With these gases some of the scavenge air also passes into the exhaust. By the time the piston has reached the bottom of its stroke the scavenge valves are closed, but the cylinder is left full of clean air ready for the compression stroke to commence.

There are different arrangements made by different makers for supplying the scavenge air. In some designs each main cylinder has its own air-compressing arrangement and receiver. In other designs sometimes one and sometimes two air pumps are provided, sometimes worked by cranks from the crank-shaft and in some cases by levers similar to the method of working air pumps in ordinary marine steam engines.

There are also different methods of applying the scavenge air, one allowing it to enter through special valves in the cylinder cover, another by admitting it at one side of the bottom of the cylinder through ports uncovered by the piston, in the same way that exhaust ports are uncovered. In this latter case, the scavenge ports are on one side and the exhaust ports on the other.

The volume of the scavenge air pumps is considerably greater than that of the cylinders, the proportion being in general not less than 1.8. This is necessary to insure that all the burnt gases be swept out of the cylinder. As the full quantity of air dealt with by the pump must pass from the reservoir into the cylinders every revolution, the pressure to which the air in the reservoir attains depends upon the scavenge-valve openings. When these are large a less pressure is required to force the air through them than when they are small. Hence the larger the openings of these valves the less load there is thrown on the scavenge air pump.

In some designs the scavenge air pressure is as much as 7 lbs. to 8 lbs. per sq. in.; in others, it is as low as 3 lbs. to 4 lbs. above the atmosphere.

In the preceding engines the pistons are of the trunk form. In the double-acting two-stroke cycle engine they are necessarily made of box form, and are fitted with piston rods, which, since they pass through the burning gases at the lower side of piston, have to be specially cooled. The pistons, also, in general, have to be cooled by either oil or water circulation. Water is the best cooling medium, as its specific heat is about three or four times that of oil, but some prefer oil, as any leakage from the water circulation washes off the lubrication of any of the rubbing parts which it touches.

The admission, fuel and other valves are designed for both the top and bottom of the cylinder. The exhaust ports are in the middle of the length of the cylinders, and the pistons, as in the single-acting engines, uncover the ports at nearly the end of the stroke.

In small engines of the single-acting type, the pistons are not water or oil-cooled, as it is found they may be kept at a sufficiently low temperature by their contact with the cylinder sides, which are water-cooled. A heated piston is not so objectionable as it is in an ordinary gas or oil engine with timed ignition, because, in the Diesel engine, pre-ignition cannot occur. The main objections are that, with a large piston, overheating of the crown may be the cause of structural weakness, and that the expansion of the metal by its high temperature renders it necessary to make the piston crown initially smaller than the cylinder bore. This has to be arranged in all engines, and the exact amount of allowance is one of those points in which experience is the only guide. It may be said here that this is a matter of extreme importance in those engines in which there are no piston rods. This will be again referred to further on. Experiments are being made in the case of an engine with a large diameter of cylinder, to ascertain whether it is practicable to run it without special piston cooling.

In all the types of engines, highly compressed air is needed for starting purposes and also for the fuel injection. This has to be supplied by an air-compressing plant worked by the main engine. The compression is sometimes performed in two stages, but a three-stage arrangement is generally used. The compressed air is cooled at each stage. The volume of the compressor is such as to provide a small surplus each revolution over that required for the fuel admission in continuous working. This surplus is stored in a reservoir constructed usually as a battery of seamless steel bottles. These are tested by hydraulic pressure to 120 atmospheres. A safety valve is provided loaded to 60 atmospheres. The compression of the air is attended by the deposition of moisture from it, so that means of draining the steel bottles should be provided.

Naturally, there are advantages and disadvantages with each type of engine, and a judicious consideration of these should determine which is the more suitable type to use in any particular case. The two-stroke double-acting engine will be higher than a single-acting one with the same diameters of cylinders and stroke, but the power will be obtained with a less number of cylinders. On the other hand, there is considerably more complexity in the valve arrangements and a probability of difficulty with piston-rod stuffing-boxes, to say nothing of the trouble of cooling the pistons and rods by water or oil circulation. There is also likely to be considerable difficulty owing to want of access for overhauling. It should be stated that no experience has been had, as yet, with large engines of this type.

Comparing single-acting engines of the two-stroke and four-stroke types, the former require only half the number of cylinders which are requisite in the latter, either to produce the same power or the same degree of uniformity of turning moment. The four-stroke, therefore, means a longer engine, and necessarily a heavier one also. The valve-gear of the two-stroke engine, being actuated by a shaft with the same rotational speed as the crankshaft, is simpler than that in a four-stroke engine, and the reversing arrangements are much less complicated. The two-stroke, however, requires the addition of the scavenge arrangements, which are absent from the four-stroke, and the necessity for supplying the energy for working these makes the mechanical efficiency less. On the question of efficiency, however, it may be urged that the four-stroke engine has to overcome the friction of the piston, etc., for what may be called two idle strokes out of every four, and this must, to some extent, counterbalance the energy necessary to work the scavenging pumps. In the four-stroke engine all the hot used gases have to escape past the exhaust valves, which thus may become abnormally heated. On the other hand, in the two-stroke engine they have to pass the bars between the exhaust ports, and it is thought by some that although these parts of the cylinder are water-jacketed, they must become overheated and lose their accuracy of surface, and it must be remembered that all the piston rings have to pass these bars every stroke. Extended experience will be required to settle all these points. It may be mentioned that an engine is being made on the four-stroke system in which the major portion of the exhaust passes out of the cylinder through ports, precisely as in the case of the two-stroke engine, leaving only a part of the burnt gases to be pushed out of the cylinder through the ordinary exhaust valves.

Indicator Cards.

It is instructive carefully to examine the indicator diagram of a Diesel engine (Fig. 1), and to compare its compression and expansion lines with adiabatic curves. When it is remembered that the circulating water abstracts about one-fourth of the total heat of combustion of the fuel, it will be seen that adiabatic conditions must be widely departed from. At the commencement of the compression the air temperature will not be very different from that of the atmosphere, and the air will no doubt receive some heat from the cylinder walls. During the compression, after its temperature rises above that of the cylinder walls, some heat must be given up, so that the pressure will not quite reach that due to adiabatic compression.

During expansion, when its temperature is so very high, it must impart a very considerable amount of heat to the cylinder walls, so that after combustion is complete, its temperature, and therefore its pressure, must fall below that due to adiabatic expansion. The fact that during nearly all the expansion the pressure is above that of the adiabatic curve shows that combustion must be taking place almost throughout the stroke, and to such an extent as to supply more heat

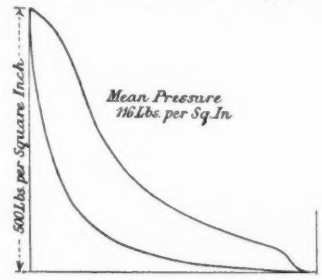


Fig. 1. Typical Indicator Card of a Two-Cycle Diesel Engine.

to the gases than is being abstracted by the cylinder sides. It is necessary for complete combustion to take place in order to prevent the fouling of the cylinders by the accumulation of carbonaceous or tarry residues, and it is this necessity for completion of the combustion, which may be termed slow, compared with the more rapid burning of the major part of the fuel admitted, which limits the amount of fuel usable per stroke. It can be readily understood that the physical condition of the pulverization of the fuel is of the greatest importance. If the spraying is not fine enough, the combustion will not be sufficiently rapid, whilst, if it is too fine, it may be so fast as to raise the pressure above 500 lbs. per sq. in., which should be the maximum obtained. It would thus appear that different adjustments of the fuel valve will be required with different qualities of oil, which may vary in their chemical composition and also in their viscosity. Further, the conditions also will to some extent depend upon the speed of the engines.

In small cylinders, only one fuel-valve is employed. It is placed centrally. In very large cylinders, it is thought that more than one must be used in order to provide for a more uniform distribution of the fuel into the compressed air, but the conditions determining the number actually necessary are matters which can only be ascertained by experience.

From the results obtained with a Carels Diesel engine in some tests made by Professor H. Ade Clark at Ghent, which were published in "Engineering" (London), August 7, 1903, it appears that the total amount of air used per stroke was 3.31 times that theoretically necessary for the complete combustion of the fuel. This shows that the limiting quantity of fuel which can be consumed in the engine depends not so much upon the oxygen supply as upon the time element, and, as above indicated, must be considerably influenced by the physical conditions of the spraying.

The large amount of air used must have a considerable influence in lessening the temperatures obtained by the combustion, but these would be almost the same whether the dilution was with clean air or whether some small part of it was composed of already burned gases. With an admixture of burned gases, such as is always present, for instance, in an unscavenged gas or

petrol engine, the combustion would probably be somewhat slower; but it is worth investigation whether, under certain conditions, which of themselves necessitated slower running of an engine, complete combustion and the consequent prevention of fouling of the cylinders would not be obtained in cases where a less than normal oxygen supply was obtainable. This point will be again referred to later on. It may be noticed that in a four-stroke cycle engine there is always a small proportion of burned air present in the charge, as the clearance space must be left full at the end of the exhaust stroke.

In dealing with large powers, it is not to be wondered at that there are different ideas amongst engineers who have had experience with Diesel engines as to the best course to adopt, viz., whether to use a large number of small cylinders or a less number of larger ones. For land engines, where very heavy flywheels can be adopted, the conditions are altogether different from those obtaining on board ship, and one, two, three or any number of cylinders can be employed, according to the choice of the builders, provided the flywheels are made sufficiently heavy to give the steadiness of motion requisite. On board ship, however, flywheels are not desirable, and very heavy ones are altogether out of the question, owing to the slowness of manoeuvring they involve.

Torsion Moment Diagrams.

In determining the number of cylinders requisite in any given case, it will be well to examine the torsion moment diagrams.

It will be seen from the indicator diagram that, when working at full power, the forward pressure starts at 500 lbs. per sq. in., and at the end of the expansion it falls to less than one-tenth of this amount; the back pressure similarly varies from atmospheric pressure at the commencement of the return stroke to about 500 lbs. at its termination. These conditions are altogether different from anything occurring in a steam engine. The effect of the inertia of the reciprocating parts, however, is considerable at full speed, lessening the maximum load upon the crank pin at the commencement of the forward stroke and augmenting it towards the end, so as to tend to give a more uniform distribution of load throughout the stroke, and similarly during the compression stroke the inertia effect also tends to uniformity.

As, however, in starting the engine, the motion has necessarily to commence at a low speed, at which the inertia effect is negligible, it is desirable to examine the torsion moment diagrams with the inertia neglected, as well as when under full-power working conditions. Figs. 2-5, showing the moments under normal working conditions, are reproduced from some kindly supplied by Messrs. Sulzer Brothers. Upon some of them have been drawn dotted lines, showing the conditions which apply upon starting, without allowing for the inertia.

In the four-cycle engine, it will be seen (Fig. 2) that with one cylinder only the torsion moment varies from 13 times the mean effective moment in a positive direction to nearly four times the mean in a negative direction, a total fluctuation of about 17 times the mean.

When four cylinders are used, the torsion moment varies, as shown in Fig. 3, from about 2¼ times the mean moment to one-tenth of the mean moment in a negative direction, the total range of stress being 2.3 times the mean. In the corresponding two-cylinder two-stroke cycle engine, the range is greater, being from a maximum of 2.8 to a minimum of — 0.68 times, or approximately 3½ times the mean stress. The figure further shows that in this case the four-stroke cycle engine will work more smoothly than the other.

Considering the four-stroke cycle engine with six cylinders, which is the smallest number of cylinders likely to be proposed with this type of engine, and the corresponding two-stroke cycle engine with three cylinders, Fig. 4 shows that in the former the stress varies from 1.85 to 0.25, a range of 1.6 times the mean, and in the latter from 2.1 to zero. The advantage again is in favor of the former.

Comparing a four-stroke engine with eight cylinders with a two-stroke single-acting with four cylinders (Fig. 5), and a double-acting engine with two cylinders, we see that all three engines have about equal variations of torsion moment, the range being from 1.75 to 0.37 in each case. With these numbers of cylinders, the motion approximates in uniformity to that obtained with a steam engine with two cranks.

If we similarly examine the diagrams of a four-stroke cycle engine with twelve cylinders, a two-stroke with six cylinders, and a double-acting with three, we find in all three engines a fairly uniform torsion moment, the ratio of maximum to mean being not greater than 1.15, which is less than is usually obtained in an ordinary triple-expansion steam engine. It may fairly be said that with these numbers of cylinders there is nothing further to be desired regarding steadiness of motion.

Best Number of Cylinders.

In deciding upon the number of cylinders to employ in any case, considerations of the turning moments point to a mimimum of six cylinders with the four-stroke cycle, of three cylinders with the two-stroke cycle, and that the larger number of cylinders employed the smoother and better the engines will work. Against this, however, is the fact that the larger the number of cylinders the greater will be the number of moving parts, and the more the attention required. More space will be demanded for the engines, which will also become more costly. With the larger number of cylinders, however, in general, owing to the more evenly distributed stresses, the smaller will be the size required for the shafting for the same power.

When very large powers are required, the question will arise as to the upper limit of size of cylinder permissible. On this point there is no actual experience. It is stated that there need be no limits of size other than those demanded for strength considerations. With larger cylinders, however, it is thought that multiple fuel admission valves will have to be employed. In general, it is thought that for very large powers it will be advisable to use more than one line of shafting, keeping the sizes and numbers of cylinders on each shaft within reasonable limits.

One point in connection with the number of cylinders is the question of handiness for manoeuvering. The engines have to be started with compressed air, and when they have commenced to move the air arrangement has to be put out of action, and the fuel supply put into gear. In the six-cylinder engines of the "Vulcanus" the starting arrangements have been subdivided, so that the change over can be first made with three cylinders, whilst the other three are still working with compressed air, after which the change can be made with the remainder. The experience of the readiness of handling which this method provides is so satisfactory that the breakdown of one of the cylinders, as has occurred in some larger engines being made by the same firm, is not noticed.

Another point in connection with the best number of cylinders to employ in any particular case arises when consideration is given to the possibility of working the engines in the event of the breakdown of one of the cylinders, connecting rods, etc. In a steam engine, many casualties may occur in which one cylinder only is disabled, and the engine can still be worked by the remaining two without a serious loss of power or speed, each of the remaining pistons getting a higher pressure upon them than when working under normal conditions. In the Diesel engine, under similar conditions, one cylinder may be disabled, and the others will still be able to work at their full pressure; the loss of work then will be less in proportion to the number of cylinders employed.

It may be here mentioned that in the four-stroke cycle engines actually made or in process of building for large ships, either six or eight cylinders are being used per shaft. In the two-stroke cycle single-acting engines, four cylinders seem to be preferred, whilst the double-acting engines being built have three cylinders. Both five and six cylinders have been proposed for the two-stroke cycle.

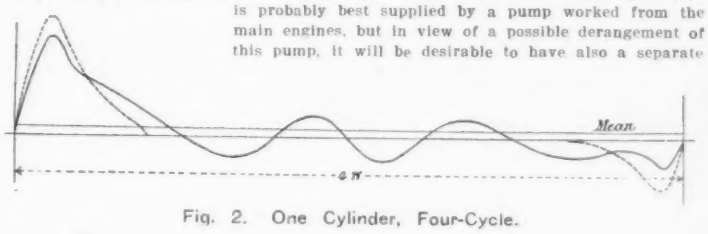


Fig. 2. One Cylinder, Four-Cycle.

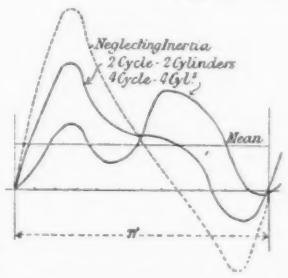


Fig. 3. Four Cylinders, Four-Cycle; and Two Cylinders, Two-Cycle.

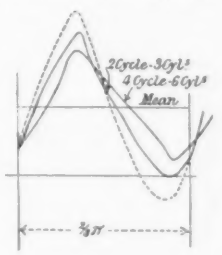


Fig. 4. Six Cylinders, Four-Cycle; and Three Cylinders, Two-Cycle.

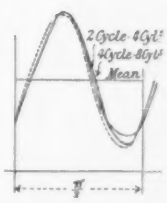


Fig. 5. Eight Cylinders, Four-Cycle; and Four Cylinders, Two-Cycle.

FIGS. 2 TO 5. TORSION MOMENT DIAGRAMS OF DIESEL ENGINES WITH FROM ONE TO EIGHT CYLINDERS.

(Dotted curves in all cases show the combined moment when inertia is not taken into account. They represent low-speed or starting conditions when the inertia effect is negligible.)

Auxiliaries.

In a steam vessel, besides the main propelling machinery, there are a number of auxiliaries, all worked by steam. It remains to be considered what would be the best way to provide for doing their work in a vessel fitted with Diesel propelling machinery. The more important are the following:

(1) Steering gear, (2) whistle, (3) donkey pumps for bilge and fire service, (4) electric-light machinery, (5) distillers, (6) steam-heating apparatus, (7) water-ballast pump, (8) winches, (9) windlass, (10) ventilating apparatus in passenger vessels.

Of these, one to six and the last are always required at sea, the remainder are generally only needed when the vessel is either in or near port. Probably for these latter the best solution is to continue the present practice of working them by steam from a donkey boiler, which may be fired with oil fuel. This boiler can be put into action only when in or about to enter port. For the remainder there are some alternatives.

The electric-light machinery presents no difficulty, as it can be worked by a small oil engine of either Diesel or other type, using the same kind of fuel as the main engine, resulting in a similar economy of fuel as will be obtained with the main engine. This engine might also be used for working the pumps for bilge and fire purposes, as these pumps are only required on emergencies when part of the electric light may be dispensed with. The ventilating apparatus can be electrically driven, the motive power being the same engine as is used for electric light. The ballast pump may be a steam pump worked from the donkey boiler, but it may be dealt with by working it by means of a small separate oil engine.

There remain the steering gear, whistle, distiller and heating appliances. The alternatives proposed are:

1. Having a donkey boiler separately fired by oil fuel continuously at work at sea for all these purposes.

2. Utilizing the heat of the exhaust gases by passing them through an auxiliary boiler, and raising sufficient steam for this purpose.

3. Working the steering gear and whistle by compressed air from the first stage of the compressor which would be made larger for the purpose.

The second alternative has much to recommend it, in view of the great quantity of heat which passes off with the exhaust gases. According to Professor A. Clark's tests, previously mentioned, nearly one-third of the total heat of combustion passes off in this way. In the four-stroke cycle engine these gases have a temperature of about 700° F., and are, therefore, capable of giving a good, useful effect in a boiler. In the two-stroke cycle, however, owing to the dilution of the hot gases with the excess of the scavenging air, the temperature will be much less, and will probably be not greater than 400° F.

Besides these auxiliaries, the Diesel engine requires others of its own. The quantity of circulating water required to keep the cylinder cool is very large. This is probably best supplied by a pump worked from the main engines, but in view of a possible derangement of this pump, it will be desirable to have also a separate connection with the ballast pump. The air compressors for supplying the compressed air used for injecting the fuel will also be worked by the main engine, but a supplementary compressor will be necessary to keep up the supply of air which is used in manoeuvering. This must be worked by a separate engine. Further, in the event of the receivers losing the air pressure from any cause, it is necessary to have another small engine which may be started without compressed air (say, a small paraffin engine), in order to obtain a sufficiency of compressed air, preferably in a small separate reservoir, to start the auxiliary compressor engine.

The size of the auxiliary compressor demands attention. When an ample volume of reservoir is provided, a comparatively small compressor is sufficient, as it can be kept working continuously, whilst the demand for air for manoeuvering is intermittent. If, however, it is desired to consider it as a provision against a breakdown of the main compressor, it must be made nearly as large as the main. The quantity of air delivered through the fuel valve depends upon the time the valve is open, and, as the proportion of this to the time taken for a revolution of the engine is fixed, it follows that each cylinder will use about the same quantity of air per minute, irrespective of the number of revolutions—that is, the air supply required will be the same whether the engine is running fast or slowly. If, therefore, a small auxiliary compressor is used for the main en-

gines, the only way to keep up the pressure necessary to inject the fuel will be to shut off some of the main cylinders entirely, working only with a similar proportion of the whole to that which the capacity of the auxiliary compressor bears to that of the main compressor. As a security against breakdown of the main compressor, therefore, it would appear that it is advisable to have it designed so that all working parts are easily accessible, and to provide a spare piece for each part which is likely to become deranged.

Modifications in Design for Marine Service.

With regard to the upkeep of the engines, much can be said. Up till recently these engines have been designed to meet conditions of service on land differing very considerably from those at sea. On land it rarely happens that the engines are worked continuously day after day without stopping, and still more rarely without a weekly stop. These give opportunities for cleaning and for small adjustments. At sea they are required to work continuously. The present marine steam engine is the result of many years' experience and evolution, and if the Diesel engine is to be successful at sea it must be made in accordance with marine-engine practice wherever possible.

On land, it is customary, for example, to have the connecting rod working on a gudgeon secured inside the trunk piston. The piston itself serves as a guide. Marine engineers are accustomed to have the gudgeon exposed to view; its adjustment can then be quickly and accurately accomplished, and it can be ascertained at every stroke whether its lubrication is satisfactory. In a double-acting steam engine, the alternate thrust and pull of the connecting rod always tend to keep the guide surfaces in contact—that is, the load on the guide is always one way, and if there is any slack there is no blow and noise. In a Diesel single-acting engine the impulse on the down-stroke and the compression on the up-stroke require the guides to be on opposite sides; hence, if there is the least slack due to wear in the guides, there is a knock both at top and bottom of the stroke. This, for an engine to run continuously, necessitates adjustable guides. The net result is that the gudgeon should be outside the piston, and should have separate adjustable guides, as in an ordinary steam engine. In other words, a piston should be used as a piston only, and should not fulfill the dual functions of piston and guide.

In land engines, it is a satisfactory arrangement to have the guides bored out to cylindrical surfaces, which can be made axially true with the cylinders. This would not be satisfactory for long in a marine engine, as, owing to the wear and possibly to the yielding of the thrust, the crankshaft gradually works forward. If the guide surfaces are plane, a little wear of this kind does not give trouble. Too much attention cannot be given to the lubrication of the pistons in the cylinders. In the steam engine practically none is required, but in the Diesel engine it is necessary that the whole of the rubbing surfaces should be well lubricated. The lubrication is forced, and the arrangement should be such that, for each part requiring it, the oil supply, drop by drop, should be visible, so as to render it positively certain that no deficiency is occurring. It is desirable, also, that the water circulation of each part should be controllable.

In marine engines built crankshafts have almost entirely superseded solid ones, and marine engineers are not likely to go back from their use. This will necessitate the strokes of Diesel engines being made longer in proportion to the diameters of the cylinders than is usual in land practice.

Much more consideration will have to be given to the accessibility of every working part than has been done in some designs. Every part of the engine which requires periodical inspection or occasional adjustment must be made easily accessible. Provision must be made for the possibility of renewing the crankshaft without lifting the engine out of the ship. In short, the Diesel marine engine should be Diesel only as regards the cylinders and their accessories, and should be of the ordinary marine type as regards all the rest of the engine.

In some designs of two-stroke cycle engine each cylinder has been arranged with its separate scavenge pump. In other designs one large double-acting pump supplies all the cylinders. In the former arrangement, if one cylinder fails from any cause, the remainder are not interfered with, and if a scavenge-pump valve gives out, only the one cylinder which the pump serves will be disabled. Where, however, one large pump serves all the cylinders, while it is recognized that the arrangement of the pump with one piston and one mechanically-worked valve is very simple and most unlikely to get out of order, yet it must be admitted that its failure, if it does occur, will occasion a complete stoppage of the engine. Possibly in recognition of this, some recent designs provide for two independent scavenge pumps, both to be in use under normal working conditions. It is improbable that both can be damaged at one time, and seeing that the air supply in each cylinder contains three times the quantity of oxygen chemically necessary for the complete combustion of the fuel, it is expected that in the event of one pump only being at work there will be sufficient air supplied to either work all the cylinders with a reduced fuel supply, or to work, say, three out of four of the cylinders at nearly full power.

[The remainder of Mr. Milton's paper takes up in detail the design of crank shafts and tunnel shafts for Diesel marine engines and will prove of great interest and value to any one called upon to design them. The following report of the discussion of th's paper at the April 6 session of the Institution of Naval Architects is an abstract of the report published in "Engineering" (London), April 14, 1911.—Ed.]

Discussion.

Dr. Diesel opened the discussion. Referring first to Mr. Milton's statement with regard to the use of tar-oils, he said that while Mr. Milton appeared to hold that the use of such oils as are made from ordinary coal-tar were of interest only in land installation, he (Dr. Diesel) thought that this was not due really to the class of engine employed. All countries which were not independent as regards liquid fuels had considerable interest in finding alternative fuels, for two reasons: (1) in order that they might become independent of foreign supplies; and (2) that the artificial raising of prices by trusts and syndicates might be impossible. No war fleet could derive the full benefits from the new prime mover if it remained dependent on other countries for its fuel, and no large industry in land engines, could develop if the price of fuel was subject to market operations such as had been known with lamp-oil. For these reasons the German makers of the Diesel engine did not let the matter rest until they had settled this question of tar-oils. Today this might be said to have been settled, and any kind of liquid fuel, natural or artificial, could be used in Diesel engines.

The way this was accomplished was to use two kinds of fuel. A small quantity of easy-burning oil was injected first, and the main quantity of the heavier oil was injected subsequently, after the temperature had already been raised by the inflammation of the lighter oil. Only one fuel-injection valve was used for both oils. An engine working on this principle was a universal engine, and could use any kind of fuel without alteration in the fuel-valve or injecting apparatus. The Diesel engine was thus independent in its choice of fuel, and there was therefore no likelihood of trouble arising from stoppage of supply or rise of prices.

With regard to Mr. Milton's statement that the weight of fuel carried for a Diesel-engine-driven ship would be only 28% of that necessary on a steamship, Dr. Diesel said the true advantage was greater. Mr. Milton's figure was based on consumption per brake horse-power, but in practice boilers had to be kept fired even when there was no work to be done. The Diesel engine only consumed oil in proportion to the actual work done. This was of great importance in warships, especially turbine-fitted vessels, where the consumption at low speeds was high compared with the power developed. This was not so with the internal-combustion engine. The proportion of fuel to be carried would, with Diesel engines, only amount to one-fifth or one-sixth that carried for a steam-driven ship.

In connection with the description of the two-stroke cycle, he would like to add that the Diesel engine was destined to be essentially a two stroke engine, for the following reasons: (1) because scavenging was done with pure air only, and not with a mixture of gas and air, so that there were no fuel losses by the scavenging; and (2) because ample scavenging air can be used, and the process made thorough in every way. He considered that the marine Diesel engine of the future would be the two-stroke cycle engine.

Mr. Milton had spoken of the oil-cooling of the pistons. This had, of course, to be accompanied by some process of cooling the oil itself in an apparatus like a surface condenser. Though this was a slight complication, oil-cooling simplified the engine itself and all the cooling devices. Broadly speaking, different kinds of fuel could be injected with one adjustment of the fuel-valve, and there was only necessary a variation in the pressures of the air used for injection. This could be arranged for by the man in charge, according to his experience. Tar oils—that is, the oils made from coal-tar—were the only class which needed the special arrangement referred to.

The question of whether many small, or a few larger, cylinders are best had not yet been settled, except as regards submarines, where only one solution of the problem was possible, on account of the restrictions of space. In this case, undoubtedly, double-acting engines would be too high. Single-acting two-stroke cycle engines were already under construction for submarine-boats of about 5,000 HP., with two propellers, there being eight cylinders per shaft and two scavenging pumps placed at both ends of the engine. With this arrangement perfect balancing could be secured, and the engine rendered free from vibrations, which was of importance. Freedom from vibration was very difficult to secure with a few large cylinders, and possibly this would have a strong influence on the question of type.

The question of the use of large double-acting cylinders would probably be settled this summer by experience with the 3,000-HP. ship of the Hamburg-American line, being built by Messrs. Blohm & Voss at Hamburg.

It was well known that a six-cylinder engine was entirely balanced if two of the six cranks were always placed in the same plane and in the same direction symmetrically about the middle of the length of the engine. Such an engine had only three different crank positions, at 120°, and only three impulses per revolution. In the Diesel engine, especially for low speeds and manoeuvering, in order to do away with the fly-wheel, it was necessary to have as many impulses as cranks, and therefore in a six-cylinder engine the cranks would have to be set at 60°. Such an engine was no longer balanced, but by adding two scavenging-pumps at both ends, and by carefully arranging the weights of their reciprocating parts and crank angles, it was possible to produce an entirely balanced engine. The same could be done with eight or more cylinders. This arrangement moreover, gave entire security in case one scavenging-pump failed. It was a better arrangement than that in which the scavenging-pump was placed under the cylinder, when proper balancing could not be secured, and when the pumps were entirely inaccessible. The modern three-stage compressor used in these engines, with inter-stage cooling, was found to be very reliable. He might point out that the quantity of the air used for the injection of the fuel increased rapidly with a decreasing number of revolutions, and was not constant as stated in the paper.

With regard to the general design of the engine, he thought that if the double-acting type was the engine of the future, then the crosshead had to be accepted. As long as the single-acting engine prevailed he thought the combined crosshead and trunk piston best. After making engines with crossheads, manufacturers had abandoned it, since it was possible with the trunk piston to provide much greater bearing surface than in the case of a crosshead, resulting in less wear. The lubrication also, under pressure, of an enclosed cylindrical guiding surface was much better than in the case of open guides, while the piston moved also over perfectly cooled walls; whereas a crosshead always tended to heat and was difficult to cool. Theoretical and practical reasons supported the use of the trunk piston and crosshead, and the only thing against it was the fact that the gudgeon-pin was inside. This, with modern systems of lubrication and oil cooling, was a very slight point. Steam-engine builders and shipowners might not readily accept these views. He had met with similar opposition twelve years ago in connection with land engines, but that had now been overcome.

While the total annual output of Diesel engines of all kinds now amounted to several millions sterling, marine engines had only been built in small sizes. He knew, however, of 250 ships fitted, or being fitted, with such engines. The most important field had, up to the present, been that of submarines, in which work France took the lead seven or eight years ago. Today all important European countries except Great Britain used these engines on submarines. Such installations ranged from 300 HP. to 5,000 HP. These boats were no longer merely weapons of defence, but were now useful in attack owing to their increased power and range of action. Russia had some Diesel engine-fitted gunboats and small cruisers. Tank-ships, with engines of 600 HP. were also running. Vessels of several other types had been equipped. This year witnessed the introduction of the engine into large cargo boats. The "Vulcanus," built at Rotterdam, made a start, others would follow; as, for instance, the 9,000-ton boat of the Hamburg-American line.

A transformation in shipbuilding and ships of war would follow. Already one cruiser fitted with Diesel engines was under construction. In connection with the equipment of war vessels he might be permitted to point out that the use of such engines would enable the radius of action to be increased so that a vessel could sail round the world, fight battles and come home again, without taking additional fuel on board, being thus independent of coaling-stations. The engine could be arranged entirely below the armored deck, with most of the machinery below the water-line. Guns could be trained to any point on the horizon, and their number and size increased. Such points as these would ultimately lead to all countries embarking upon great changes in war-ship construction.

At the close of Dr. Diesel's remarks, Sir William White inquired if he could give any information as to the largest power now used in a single cylinder on the Diesel system. Dr. Diesel replied to the effect that he hoped later speakers would give information on the point, but as far as he knew, the highest figure was

1,000 HP. (for a single cylinder); the engine was a two-stroke double-acting Diesel engine.

The second speaker was Dr. Bruhms. He opened his speech by saying that Mr. Milton had stated that the volume of the scavenging air-pumps should be about 1.8 times greater than the working cylinders. According to the experience of the speaker's firm, this was rather high; it was sufficient, he thought, in long-stroke, slow-running engines to have a volume of 1.2 to 1.25, and in quick-running engines with short stroke—as submarines and torpedo-boats—this volume should be increased to 1.5. The volume of these scavenging air-pumps should not be greater than was absolutely necessary. It was not important for the air within the cylinder to be absolutely pure; some residues might remain, and the efficiency of the engines would not be disturbed. But if the pumps were too large there was a great loss in extra work.

It was, however, of great importance to so arrange the scavenging air-pumps that there was a constant pressure in the receiver into which the air passed from the pumps and then to the cylinders. If this pressure were constant, it could be rather low. In reversible engines this receiver should always be small, so that the necessary constant pressure could be raised very quickly. Otherwise there was danger that the engine would not start up promptly. For these reasons he would not advise the use of only one pump; it was better to have at least three pumps, in which case it was possible to have a nearly constant pressure in the receiver.

Mr. Milton had also spoken of the number of engine cylinders. According to the speakers' experience, by arranging to dispense with the flywheel it was possible to avoid very serious trouble and danger. At the works at Nuremberg, they had made trials of a three-cylinder double-acting engine, and they had found very serious torsional strains in the crank-shaft. These disappeared when they took off the flywheel, and they had therefore come to the conclusion that there should be sufficient cylinders to avoid the need of a flywheel, but not more. For the purpose it was enough to have in two-cycle engines three double-acting cylinders or six single-acting cylinders. If such engines had a flywheel, the danger of strains or of heavy vibrations within the crank-shaft was always present. In their case, as they had had many failures with flywheels, they intended to try to get along without them. Three double-acting cylinders were sufficient to give a torsional moment which never became negative, so that the engines could run without a flywheel.

With such an engine, it was possible to diminish the number of revolutions to one-third or one-fourth of the higher speeds; that was to say, engines of 120 to 150 r. p. m. could be run at 30 to 40 r. p. m.

The author had also spoken of the difficulty with piston-rod stuffing boxes. In the works at Nuremberg they had made an immense number of gas-engines of the double-acting four-cycle type, which involved some 1,500 stuffing-boxes, some of which had been running ten years and more. At first they had had difficulties, but these had been quite overcome.

The single-acting engine with the trunk piston, of which Dr. Diesel had spoken, always resulted in smoke issuing from the lower end of the cylinder, and this in a closed engine-room was not only uncomfortable, but also dangerous to the crew. If the engine were double-acting, and the stuffing-boxes had a small chamber from which the gases were drawn off and led to the suction-chamber of the scavenging-pumps, no smoke would issue from the stuffing-boxes. Care, of course, should be taken to see that the stuffing-boxes were sufficiently tight. With a double-acting engine a crosshead must always be used. Dr. Diesel was, the speaker thought, right in saying that for engines for stationary purposes trunk pistons presented no difficulties. The speaker was of the opinion that such pistons, however, would not do for marine engines. The marine engineers always desired a crosshead, and therefore they should have double-acting engines. The single-acting engine if fitted with crossheads was more expensive, and was also more dangerous, on account of the very long crank-shaft.

With regard to cooling of the piston and piston-rods, up to now they had always used lubricating oil. They had also tried water for this purpose, but feared that if the pipes carrying it to the piston and piston-rods were not absolutely tight, the water would get into the oil within the bilge of the engine, and in the end endanger the bearings. With regard to the question that with the two-stroke engine the bars of the exhaust-ports might become overheated, he had up to the present known no such trouble. It should not be forgotten that the exhaust-gases were seldom hotter than 400° C.; this was not high enough to cause trouble with the cast iron. Many accidents, caused by valve failures, had occurred with engines having a large number of cylinders, but never with four or six-cylinder engines. It might, therefore, be assumed that with the 8 or 10-cylinder engine there was more risk of the cylinder gear breaking down.

With regard to auxiliary engines, one of the alternative methods which Mr. Milton had proposed was a donkey-boiler separately fired by oil for continuous work at sea. The speaker did not believe it possible to use exhaust gases for this purpose. In two-cycle engines about 40% of the thermal units were used for working, 40% were absorbed by the cooling water and only 20% remained within the exhaust gases. Only in very large plants, therefore, would there be a sufficient amount of heat in the exhaust for heating a boiler. He believed a good arrangement would be that in which a donkey boiler was used only when in harbor for working the winches and capstans, and for heating. At sea the heating apparatus could be switched over to utilize the exhaust gases, while the steering-gear and all necessary pumps should be worked by electricity. This could be generated by the compressor engine or by a special auxiliary engine.

In conclusion, the speaker referred to the question which Sir William White had put to Dr. Diesel as to the largest power for one single cylinder. He said that cylinders of 300 to 500 HP. were running, and had given no trouble. In their works they had made large gas-engines which worked with 3,000 to 3,500 HP. on one crank only, and he could see no reason against building engines of 2,500 HP. in one cylinder.

Dr. Kroos, of Amsterdam followed. His firm owned the only sea-going vessel fitted with the Diesel motor engine for commercial use—the "Vulcanus." This vessel had made several long-distance and consecutive voyages, and he would endeavor to place before the meeting a few of the difficulties experienced, which, however, were being gradually overcome. Diesel engines had been in use by his firm for a number of years. The ordinary builder of land engines was, unfortunately, not acquainted with what the sea engine was required to do, and only by going to the practical marine engineer was it possible to obtain an engine suitable for driving a heavy cargo-ship at an economical speed. The land engineer was wholly unfamiliar with the conditions the marine engine had to meet. Although the Diesel land engine had given excellent results, there were many minor details in connection with the marine engine, such as that in the "Vulcanus," which had taxed the designer's ability.

The first voyage of the "Vulcanus" was made from Rotterdam to Hamburg and back, the only trouble experienced being with the air-pumps. This was, however, very trivial, and easily remedied. On the second voyage, made to Granton, the vessel encountered very heavy weather, the seas breaking over the ship and water going down the funnel. The extra strain put upon the air pumps, through the engines, caused a lever to snap. This new trouble was got over at Granton by making new and stronger levers, since which there had been no further trouble whatever with the air pumps. The vessel was then sent on a third voyage, and the defects found after this trip were of very minor consequence. Overhauling was found to have been unnecessary, and the ship proceeded again without repairs.

On the second voyage there had been trouble with the piston rings seizing. This was due to incomplete combustion. This must have been caused by the intake air valve getting choked. He would explain that a new pipe had been put on the air valve, and had been covered with wire gauze. This gauze had become choked and prevented the proper quantity of air being supplied. This was easily remedied.

On the question of cooling water versus air, it had been found in the case of the smaller Diesel engines that neither water nor air was necessary. In the engines of the "Vulcanus," air was employed for cooling the cylinders, with very good results. For engines just ordered by his company, and now being constructed, however, water cooling would be adopted.

Dr. Diesel and Dr. Bruhms had spoken of pistons and crossheads. He would say that his firm merely kept reliability in view. Long pistons were liable to bend slightly at one side, and in doing so the piston seized, after which it might occupy half a day to get them working again. He considered that this seizing of the piston, as it might stop the ship for several hours, was a source of great danger. With the heavier proportions he had adopted, this seizing would not occur. It was to avoid this that he had adopted the pistons and crossheads he used. Dr. Diesel had said that trunk pistons offered no objections in land practice. In his own experiments he had had 20 or 30 cases, at least, of such pistons seizing badly. In the crosshead type the piston did not stick in that manner.

The discussion was continued by Dr. Paul Rieppel, who said that Mr. Milton had referred to the paper which the speaker had published some four years ago on the combustion process in oil engines. The oil engine business had meanwhile rapidly increased, and for that reason the question of experiments had become of greater interest and importance. He hoped that some firm or engineer would continue his experiments and test the behavior of oil at very high temperatures and pressures, in order to determine the exact rules for combustion in the engine and to be able to decide if an oil were good or not. In such a case he would be glad to assist with any further information he had.

Mr. Milton had also referred to experiments made with uncooled pistons. It might be of interest, in that connection, to say that in America there had been running for eight months a four-cycle double-acting engine of small size, which was doing well with uncooled pistons. This engine was built by the Southwark Foundry Co., and was, so far as he knew, a solitary case of a double-acting engine running without special cooling.

With regard to the possible difficulties, owing to want of access for overhauling, he considered it feasible to build double-acting engines equally accessible as the ordinary steam engine in ships. He highly appreciated what the author of the paper and Mr. Kroos had said on separate pistons and crossheads on single-acting two-cycle engines, and on this point he was sorry that he could not agree with Dr. Diesel. The piston should be used as a piston only, in the case of marine engines.

Mr. Westgarth stated that Messrs. Carels Frères, with whom his firm were working in building Diesel engines, had already made and run experimentally a single-acting single-cylinder engine of the two-stroke cycle of 1,200 HP.; this engine promised well. He agreed generally with the conclusions that the Diesel and other marine oil engines should resemble as much as possible an ordinary marine steam engine. He considered that the author's suggestion relative to the size of the scavenge air pump were excessive. The author had presumed that there would be as much air used with the engine running slowly as when running fast. Makers were overcoming that, and would not use so much air when running slowly as when on full power.

It might be of interest if he submitted particulars of what was now being done by Messrs. Richardsons, Westgarth & Co. Lord Furness, in speaking to him, some time ago, said that if they could put a reasonable proposal for an oil-engine-driven ship before him, he would lay down the ship and give the firm an order for the engines. Messrs. Dixon were finally commissioned to build a ship to carry 3,100 to 3,200 tons total dead weight—about 275 ft. long. The ship would be exactly like certain existing ones, except in regard to the finer lines aft, which were obtainable owing to the smaller diameter and faster running of the propeller. In the final comparison, therefore, something would have to be allowed for this difference; but it would have been foolish to spoil the experiment by adhering too slavishly to the idea of making the ships exact duplicates.

The engine room had been reduced as much as possible consistent with getting the 32% reduction in tonnage under Board of Trade rules. By carrying the fuel oil largely in ballast tanks the usual coal bunkers could be dispensed with, and something like 8,000 cu. ft. to 10,000 cu. ft. of hold capacity was gained. Then there was the saving effected in dead-weight carrying capacity. For reasons which he would explain later, the engines were heavy; but, even so, nearly 100 tons were saved, as compared with the weight of engines and boilers in the steamship.

The difference in the weight of fuel consumed as between coal and oil would show a saving of nearly 9 tons per day for ordinary work in the trades concerned. If the figure were put at 8 tons per day, as these particular ships bunkered for twenty-five days' steaming, some 200 tons were saved for payable cargo. There were, therefore, great advantages, provided they were not secured at too great a cost. As regards the propelling machinery, the cost of oil engines would be more than the cost of the ordinary steam engines for cargo boats.

Coming to the question of the engines, they were working with the English Diesel Co. (Carels Frères, of Ghent). Although they started, of course, with due consideration of the fact that they wanted to economize fuel and weight, they had no intention of doing that at the expense of reliability. It was, therefore, decided that the engine should be a slow-running one and strong, and therefore rather heavy. Notwithstanding this, as had been said, nearly 100 tons could be saved in the weight of the machinery. The speaker did not agree with Dr. Diesel that the connecting rod top ends should be within the trunks, and it had been decided in this case that they must be outside. It was also decided that the engine should not have forced lubrication, but must be open and slow running, so that any seagoing engineer would see that he had practically an ordinary marine engine with a little bit extra on the top, perhaps.

The engine adopted had four cranks, was of the four-cylinder, two-stroke, single-acting type. It was not the most economical engine in weight, and certainly not in cost, but these considerations were put aside. They had finally come down to four cranks, as that seemed to be as many as was consistent with reducing the working parts. The crankshaft was made in two interchangeable pieces of two cranks each. The low-pressure air pump and scavenge pump were at first designed to work in line with the cylinders, but that plan destroyed the interchangeability of the shaft. Again, the ordinary

engineer would prefer pumps like those with which he was familiar, so they had applied the ordinary system of levers with the pumps at the back of the engine.

The compressing pumps were divided into two units, so that instead of one air pump there were two, each being rather larger than half capacity, so that if one broke down the ship had still a reasonable chance of getting home. The water pumps for circulating, the usual bilge pumps and the oil pumps were made and worked in the usual way. The high-pressure compressor was one of Reavell's three-stage rotary pumps, fitted on the forward end of the crankshaft.

There was a small flywheel, and the shafting was, of course, as usual; but the propeller was rather different. He thought the importance of the propeller efficiency for cargo boats was not entirely grasped. Using a propeller of as large diameter as possible (as this was an ordinary cargo boat), it was necessary to reduce the number of revolutions; the latter were gradually brought down until the engine was run at only 115 r.p.m. In that way, it was thought, an engine would be constructed which almost anyone could deal with. In reply to an inquiry, Mr. Westgarth added that the number of revolutions in the case of corresponding steam-engined ships was 80.

A great deal of consideration had been given to the matter of auxiliaries. Naturally, it was desired to dispense with steam on board, and the first idea was to have a Diesel auxiliary engine to operate either a dynamo or an air compressor. It appeared that all the auxiliary machinery, both in the engine room and on deck, could be worked either by compressed air or by electricity; but on going further into the question, difficulties arose in both systems. He was certain, however, that both these systems would ultimately be perfected. As, however, the ship was to be an ordinary trading vessel, it was thought better, at first, to reduce the number of "experiments" on board to the minimum. It was therefore decided that steam should be used for the auxiliaries, the only "experiment" being the main Diesel engine.

The donkey boiler plant, necessary for working the cargo, would be divided into two units, so that one of the smaller donkey boilers could be kept under steam at sea with either coal or oil—probably the latter—for the steering gear, and, when necessary, for working the auxiliary compressor and the auxiliary pumps. Such a ship would want three engineers, and three donkeymen instead of five firemen. Thus there would be a saving equal to the wages of two firemen.

Then there was the all-important question of oil supplies. He had made many inquiries, and was surprised to find at how many places in the world suitable oil could be got. Oil could be bought now in reasonable quantities, such as would be required for bunkering, in many ports in England, including London, for $10 or less per ton, put on board; and considering that there was only one-third—Dr. Diesel had said one-fifth or one-sixth—the weight of oil needed as was required of coal, the cost was pretty much the same. The different oil companies were gradually extending their points of supply; indeed, so fully awake were the companies to this necessity that they were quite prepared to undertake the supply of oil wherever it was called for in reasonable quantities. Undoubtedly the prudent shipowner, before ordering a ship with oil engines, should consider very carefully his arrangements for getting supplies of the fuel.

Mr. Foster King said he hoped that in the desire to obtain the maximum results from the new development in the way of capacity, the risks of storing all the fuel in the double bottom and in other places liable to external damage would not be forgotten, or ships might be left helpless in some place where they could not get oil. He would suggest, therefore, the provision of a reserve tank, with a reasonable supply, removed from the skin of the ship.

Mr. E. Hall-Brown, who followed, said he thought the paper contained much information and much suggestive thought, which would be of great value to engineers and shipbuilders; but, in relation to shipowners, he feared it might prove absolutely misleading, unless the discussion brought out a more correct estimate of the relative economy to be obtained from Diesel engines, as compared with steam engines, for the propulsion of ordinary merchant ships. The author had also said that the chief inducement to forsake the steam engine would be mainly, if not solely, the question of fuel economy. Before discussing that point he would say that he did not consider that the internal-combustion engine using oil possessed many advantages, for marine work, over one using gas or coal. That opinion might, of course, be disputed. Although Mr. Milton had at first stated that the advantages of the use of oil over coal in boiler furnaces were very great, he had afterwards pointed out that in the ordinary cargo steamer, which had to seek employment all over the globe, coal was still a necessary fuel. He was of opinion that it was, in all probability, the more economical fuel from the point of view of cost.

In the ordinary cargo steamer, engaged in the ordinary carrying trade, and having a speed of 11 knots, the mechanical efficiency of the ordinary marine engine was given by Mr. Milton as 85%; that, he would say, was a very low estimate, and he thought the figure need not be less than 93%, or even higher. He had known several cases in which the efficiency percentage was not less than 94%; but 93% might be taken as a fair figure. That made a considerable difference in the estimate of the cost of fuel. It brought the 1.47 lbs. given by Mr. Milton for the steam engine down to 1.34 lbs. The corresponding proportion was about 30%, the Diesel engine using about 30% of the weight of fuel of the steam engine.

It should be remembered that one ton of oil would cost $11, while the price of coal might be anything from $2.50 onwards, so that the cost of fuel for 1,000 B.HP. for the Diesel engine would be $47, whilst coal for the steam engine of the same B.HP. at $3 per ton would be $42 per day, showing a saving of over $5 per day in favor of the steam engine.

The matter did not end there. The marine engine existed to drive the propeller, and if, for any reason, the propeller efficiency was lower with the Diesel engine than with the steam engine, the position of the latter would be further improved. This, it would seem, would invariably be the case. The Diesel engine must, for an ordinary cargo vessel, run at a higher number of revolutions than would correspond to the most efficient propeller.

Few examples could be cited, but taking the "Vulcanus" mentioned in the paper (having a length of 196 ft., a beam of 37 ft., a draft of 9 ft., and a displacement of 1,900 tons), this vessel was said to have made 8.4 knots on trial with a Diesel engine of 550 B.HP., running at 130 r.p.m. Put shortly, a steam engine to do the same work need not be of more than 500 I.HP., and 8 knots at sea would be got easily for 450 I.HP. The ship was said to require 2½ tons of oil per day, costing $27.34, whereas coal for 450 I.HP. cost $17.50, or a saving of $9.80 per day on the steam engine.

On the question of lubricating, he thought the lubricating oil was a very substantial item in all internal-combustion engines, and was very much in excess of anything required for the steam engine. He did not consider that the personnel would be found to be reduced by the use of the Diesel engine, in view of the large amount of auxiliary machinery, although, of course, fewer stokers were required. He did not yield to anyone in his admiration of the Diesel engine as a piece of engineering. He believed it had its legitimate application, even in marine propulsion; but every point must be considered, and the pros and cons duly weighed before its application in every case was advised as a general solution to the problem of marine propulsion, particularly in the case of vessels of the type with which he had been dealing. He did not think that at the present time the marine Diesel engine was a commercial proposition.

Mr. L. Smart said the first Diesel engine put into a boat in this country was put into a towing craft, and the engine, of 35 B.HP., had justified the English Diesel Co. in their assertion that the engine would work efficiently through a wide range of revolutions per minute. The fuel economy came out at practically the figure given in Mr. Milton's paper. That engine was designed to run at 260 r. p. m., and it ran for hours quite satisfactorily at practically half that speed. Mr. Smart thought the saving, by using Diesel engines, in screw space, stokehold and bunker space, especially on long voyages where measurement cargo was carried, would be more important than fuel economy.

Diesel engines were not found to be more costly than first-class steam engines and boilers in repairs and renewals. For instance, two Diesel engines, driving on the same shafting, after running continuously for seven or eight years, during which time they had never had a thorough overhaul, were last year dismantled and were found to be in such good condition that they were put together again with but very little repair work. They were each of 80 HP. The cylinders had not worn taper, but had worn oval by about 2/1000 in. They had run about 30,000 hours, and their fuel consumption just before being laid off was about 0.43 lb. per HP. at about 80% load. As they were in a mill, some of the heavy band saws taking 50 HP., their work was very rough.

The replacements were principally of new valves. During the last three years they had aggregated for the two engines $366.50, or about $60 per engine per annum. For overhauls during the same three years, including the dismantling after seven years' work, the cost was $585, or about $97.50 per engine per annum. The Diesel engine required a class of workmanship far beyond that usually considered necessary in marine engine practice. In the installation, also, precautions were necessary, as, for instance, with regard to preventing grit getting into the air compressor working up to 800 lbs. per sq. in. This, if allowed, would cause trouble.

Mr. Smart thought there was a great future for the Diesel engine, using gas made from coal. This was important, for, if the Diesel engine became common for marine use, the price of suitable oil might go up. On the ordinary trade route from London to Japan there were something like seventeen or eighteen ports at which oil could be procured, and others not far removed from the route. The price at many of these places worked out at less per unit than that of first-quality coal. Many, if not most, of the crude oils had asphaltum in solution; such oils should not be used.

If the auxiliaries were calculated at 20% of the main engine requirements, he thought that the total fuel consumption could be brought down by the Diesel engine to 25% of the amount necessary with steam-driven engines, instead of the 28% mentioned by Mr. Milton.

From seven to eight years' experience of these engines he would hardly like to start with them to New Zealand, with only a chance of cleaning the valves at Cape Town.

Mr. A. P. Chalkley said the strategic value of the Diesel engine for warships was, he thought, not fully understood. At present, Germany would be greatly handicapped in a naval war by the absence of coaling stations, and for that reason could not take the offensive in a great war. As four times the radius could be obtained for any battleship fitted with Diesel engines, the adoption of this system would entirely do away with Germany's disadvantage. The Diesel engine had been running for seventeen years, and might therefore be considered fairly reliable.

He thought that all auxiliaries might be electrically driven. The steering gear was electrically driven already on most of the Russian and United States battleships, and there was not much to be feared in that direction. With regard to ultimate saving from fuel, pricing coal at $3.40 a ton and oil at $10, the saving could, in any case, always be made out at 30% in actual fuel cost. In the "Vulcanus," where the power was about 500 HP., he understood the saving was about $19.50 per day.

Mr. W. Russell spoke on the question of auxiliaries. Allusion had been made to the compressor made by his firm, and it might be of interest to state that they were then constructing a compressor for a ship with engines of about 2,000 HP. They were also studying how compressed air could be efficiently used for the purpose of working deck machinery and steering machinery, and had erected an experimental plant in which the heat of the exhaust of the Diesel engine was used to heat the air for working the deck machinery. The experiments showed that while the heat was easily imparted to the air after compression, unless lagging were very carefully carried out it was not easy to keep much of it till the air reached the machinery.

Mr. Westgarth had stated, in relation to their ship, that the intention was to use steam for steering at sea. He was interested in a Continental ship of larger power, and it was the intention in that case to go a step further, though he agreed that Mr. Westgarth was wise in trying one thing at a time. It was, however, the intention on the Continent to construct the compressors so that they would supply air for steering engines, and thus, after leaving port, it would be possible to shut down the steam plant. In order to obtain data for this, Mr. Westgarth and Sir Raylton Dixon had allowed his firm to make careful experiments as to the quantity of air needed, and the necessary pressure, for working an ordinary steering engine. The ship on which the experiments were made was of some 8,000 tons, so that the information was of service. Investigation showed that when the rudder was moving through only a few degrees the pressure needed for steering engines was low, but when turning with the extreme angle of helm a pressure of 80 lbs. or 90 lbs. would have to be provided. With regard to the requirements on the high seas, they had been able to make trials on a ship proceeding from Dover to New York. As a result, it seemed quite possible to steer at sea by means of air with a reasonably small compressor.

When steam was used for deck machinery it was a simple matter to put in a winch of large enough capacity to handle the occasional large loads, because the steam and water supplies in the boiler would enable it to do the lift when called upon. When, however, compressed air was used, a compressor of a certain size must be put in, and if the winch were called upon to do more work than the compressor would enable it to do, the pressure fell, and the operation became exceedingly slow. When, therefore, a shipowner contemplated the purchase of a Diesel-engined ship, and was considering the question of auxiliaries, he would need to go very carefully into the question of average rates of loads required. The use of air for dealing with cargo as well as steering was quite a feasible and sound mechanical proposition.

Sir William White said the paper and discussion had impressed upon him the fact that the question of using internal-combustion engines for ship propulsion had made a remarkable advance within the past few years. But we were only on the threshold of the subject.

When Mr. McKechnie's paper was read in 1907, that author's experience had been restricted to an engine of 800 HP. The powers of engines mentioned in the discussion indicated a great advance. He felt that they were under a great obligation to Mr. Milton, and was sure that the result of the paper and the debate would be most profitable.

Mr. Milton then replied to the discussion. The Institution, he had no doubt, felt exceedingly honored by the presence of Dr. Diesel, Dr. Bruhms, Dr. Rieppel and Dr. Kroos, and by the assistance they had given to a consideration of the subject. With regard to reversibility, the Diesel engine could be made reversible with certainty. Being easily startable in any one direction, ahead or astern, the engines would, of course, be equally easily reversible as well as thoroughly reliable in this respect. He was pleased to hear Dr. Bruhms say that he had no trouble with stuffing-boxes; in view of his large experience with gas engines, he thought Dr. Bruhms should be able to speak with confidence on the matter. In other cases experience had not been altogether favorable, and he had been told that, although improved, stuffing-boxes were not yet perfected.

He was pleased also to hear Mr. Westgarth's statement of an engine of 1,200 HP. in one cylinder having been made, and Dr. Bruhms' to the effect that there would be no difficulty in going to double that power on the crank. Such developments promised well for the future of the Diesel engine for marine purposes. Mr. Westgarth had clearly shown that it was not the cost of fuel only which made an engine economical, but it was partly due to incidental savings, coupled with not having to carry so much fuel.

Replying to a question as to whether funnels were necessary, Mr. Milton pointed out that they were of less importance on a ship that did not burn coal, and that the gases could be got rid of, as in a small craft, without funnels.

Short-Span Bridges of I-Beams and Concrete on the Orleans Railway (France).

In 1910, the Orleans Ry. (France) had to replace some 60 old cast-iron girder bridges of 13.12 to 19.68 ft. span, which were not strong enough to carry the new locomotives. In order to reduce maintenance to a minimum it was decided to use groups of steel I-beams embedded in concrete. It was necessary to build these spans in advance, and not place them until the concrete had thoroughly set; to concrete them in place would have necessitated considerable interference with the traffic. The method of handling and transporting the completed slabs was a problem, on account of their weight, and to limit the weight a special arrangement of slabs was used. Each bridge consists practically of three parts: (1) two slabs (9.84 ft. wide) composed of I-beams and concrete, one slab under each track; (2) a central portion composed of several light slabs of reinforced concrete, resting on the track slabs; (3) two sidewalks of reinforced-concrete slabs resting on the abutments. These parts are lettered (A), (B) and (C) respectively in Fig. 1. For the track slabs, the steel beams were made of sufficient strength for the loads, no allowance being made for additional strength due to the concrete.

Each track slab of 13.12 ft. span is composed of two girders or ribs, each of which has three 12½-in. I-beams connected by bracing and riveted at each end to angle connections on the web of a transverse 16-in. I-beam. On top of each girder are pairs of transverse angles (D) to which the ties are secured by straps and bolts. The spaces between the beams are filled with concrete, and the space between the ribs is closed by a reinforced-concrete panel or slab. Cantilever extensions of this panel on either side form seats for the central and side slabs (B) and (C). At each end of the slab is a transverse rib 12 ins. wide, which serves to distribute the load properly on the abutments, and at intervals are intermediate ribs enclosing the tie-rods which connect the two groups of I-beams. For the spans of 19.68 ft. each longitudinal rib has four I-beams. The weight of the slab (single track) is about 12 tons for the shorter and 20 tons for the longer spans.

The preliminary work included dressing the top faces of the abutments to receive the slabs, raising the track when the depth of the slab was greater than that of the old girders, and replacing the regular track rails by short sections to permit of convenient removal and replacement of the span.

The changing of the spans was carried out rapidly by means of a special bridge crane devised by the contractors, Messrs. Moisant, Laurent & Savey. This machine (Fig. 2) consisted of two plate girders braced together at the top and resting at each end on a cross frame on a pivoted bolster on a 20-ton flat car. These cars were 59 ft. c. to c., with a clear space of 32 ft. between them. Between the girders were two tracks (A) for three trolley carriers. From two of these carriers was slung the new span, and the third was to carry the old span (of much lighter weight). The chains were attached to hoisting tackle. At each end of the girder was a platform for the hand winches or hoists, five at one end and three at the other.

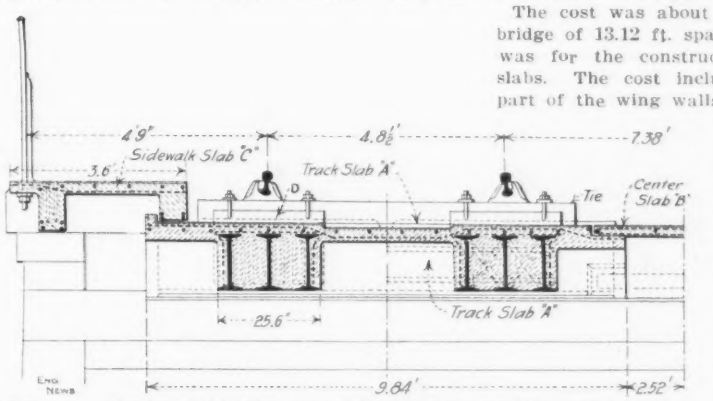


FIG. 1. CROSS SECTION OF CONCRETED I-BEAM BRIDGE FOR SHORT SPANS; ORLEANS RAILWAY (FRANCE).

The slabs were shipped to the stations nearest the work. The crane was placed in position over a turntable, its trucks were blocked and the coupling bars (B) between them were removed. The truck carrying the track slab was then run under the girder. As soon as the slab was slung in place (as shown) the chains were wound up by the winches, a supporting girder was placed under it and the upper side was blocked against the bottom of the crane girder so as to prevent any swinging. The sidewalk slab was run alongside the crane car on a truck, and was placed on top of the girder (as shown in Fig. 2) by two 2,200-lb. revolving hoists (D) which traveled upon the girder.

When the machine was loaded it was hauled to the bridge by horses, and its trucks blocked. The short pieces of rails on the bridge were removed (for one track) the coupling bars between the trucks were removed, and the slab was swung free. The single trolley hoist (E) then raised the old span and carried it to one end of the crane girder, out of the way. The double hoists carried the slab into position, the masonry of the abutments was leveled, and the slab lowered into place. The sidewalk slab was then set in place by the two upper trolleys, while the rails were being replaced. The machine was then run back to the station to unload the old span, and to pick up the second track slab and sidewalk slab. The operation lasted about an hour, from the time the rails were disconnected till they were reconnected. The unloading and reloading at the station took from 1½ to 2 hours.

The cost was about $1,000 to $1,600 for each bridge of 13.12 ft. span, and about $800 of this was for the construction and placing of the slabs. The cost included removing the upper part of the wing walls to admit the wider floor construction of the new spans, also the widening of the roadbed and placing additional ballast. Steel bridges would have cost from $1,300 to $1,400. Under loading tests, the deflections were very slight. In point of stiffness and of maintenance cost these beam-and-concrete spans are considered superior to ordinary steel spans. The above particulars are from an article by Mr. M. Balling, Engineer of Maintenance of Way of the Orleans Ry., in the "Revue Generale des Chemins de Fer" for February, 1911.

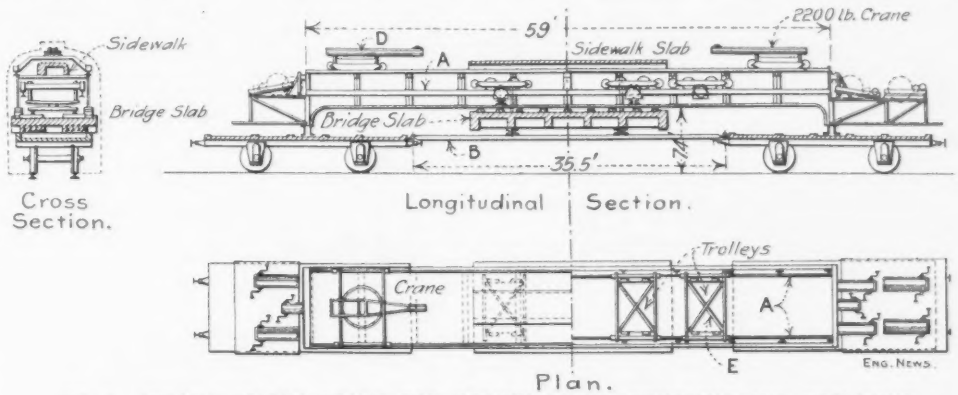


FIG. 2. SPECIAL BRIDGE CRANE FOR TRANSPORTING, REMOVING AND REPLACING SHORT BRIDGE SPANS; ORLEANS RAILWAY (FRANCE).

THE PROPOSED INLAND WATERWAY from Boston Harbor to Narragansett Bay has been reported upon by a special commission created by authority of the state. Two routes for the canal were proposed; one from Taunton to Plymouth and the other from Taunton to Hingham. Estimates were made by the United States Engineers for a canal with a depth of 25 ft. and a bottom width of 200 ft. The length of the canal route from Taunton to Plymouth is 37 miles. The estimated cost of construction at sea level is $47,133,000 and the annual cost of maintenance, capitalized at 4%, would amount to $11,835,000 more. For a lock canal, with a 20-ft. summit level, the cost would be reduced to $26,848,000, but the annual cost of maintenance, capitalized at 4%, would be $14,785,000. By the route from Taunton to Hingham, the distance would be 52 miles, and the total cost, including capitalized cost of maintenance, would be about $61,000,000.

The investigations of the commission as to the probable traffic of the route indicate that the amount of traffic which the canal could obtain would not justify the state or the nation in undertaking its construction. The final conclusions of the commission are as follows:

(1) It is doubtful as to what extent sea-going steamers, both cargo and combined cargo and passenger vessels in the coastwise trade, would use the canal.

(2) Sailing vessels would not use this canal under ordinary weather conditions, and on account of cost of towage would not use it except under extraordinary circumstances.

(3) It is probable that a fair proportion of the present coal barge traffic around the Cape would use the canal.

(4) The saving on coal freight to Boston harbor would not exceed 5 cts. per ton, on possibly 4,000,000 tons.

(5) If sailing vessels will not use the canal and only a portion of the barge traffic will use it, a part only of the loss of life and property incurred in navigation around Cape Cod would be saved by the construction of the canal.

(6) It is probable that there would be some coal brought to Boston in box or other cheap barges which cannot now take the outside route. There would be a saving in freight on this traffic.

(7) There would be some benefit to local industries and inhabitants of towns on or near the route of the canal by the introduction of competing water transportation.

(8) As to the possible industrial development on the route of the canal, there is no doubt that additional sites would be available, having water transportation, but it must be remembered that the state already includes much property yet unused having these advantages.

Recommended Jobbing Shop Practice in Designing, Drafting and Cutting Spur and Bevel Gears.

By G. A. BISSET.*

Having acquired at the Navy Yards an interest in the general subject of gear cutting, the writer has taken advantage of the opportunity of studying the question in private establishments, where it is assumed, from the amount of business being done, that the processes are at least approximately up-to-date. While the investigation was designed to acquire information which would be of use in future navy yard experience, it is believed that much of the information will be of interest to privately operated machine shops.

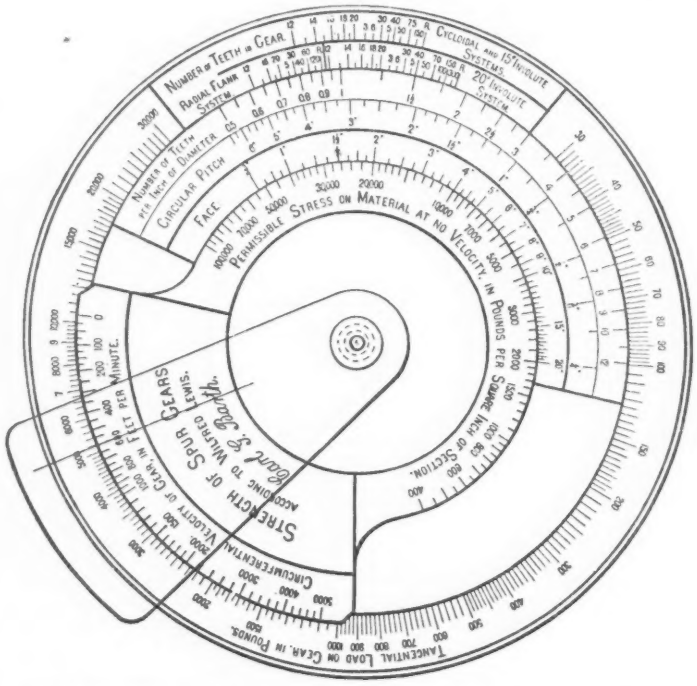

Number of Teeth in Gear
Radial Flank System
Number of Teeth per Inch of Diameter
Circular Pitch
Face
Permissible Stress on Material at No Velocity, in Pounds per Square Inch of Section.
Strength of Gears
According to Wilfred Lewis.
Barth's Slide Rule
Circumferential Velocity of Gear in Feet per Minute.
Tangential Load on Gear, in Pounds.
Cycloidal and 15° Involute Systems
20° Involute System

FIG. 1. BARTH'S SLIDE RULE FOR DESIGNING SPUR GEARS.

At a navy yard, the machine shop must be able to cut a large variety of gears, but is seldom called upon to make a large number of any one design. In fact, the gears cut are usually odds and ends required for repair work, or for use in the very limited number of machines manufactured in the Navy Yard shops. The requirements of a navy yard machine shop are, therefore, very similar to those of an ordinary machine shop where jobbing work is done, or to the machine shops which are part of the "repair" establishment of a large industrial plant or railway machine shops such, for example, as the repair shop of the Carnegie Steel Co.'s works at Homestead.

As a result of this investigation, the writer has formed opinions as set forth below. The effort has been made to present the material in such a way that it will include the chief information required in the drafting room and machine shop for the cutting of bevel and spur gears.

General Considerations.

No gear should have cast teeth; the teeth should be cut, either from cast blanks or forged blanks. The superiority of the cut teeth is most manifest in the reduction of friction and noise, while the increased life of the gear is very appreciable. The cost of cut gears where the workman or foreman understands the process is very little, if any, greater than the cost of gears with cast teeth.

In order that the workman may acquire the necessary knowledge with the least output of effort, the number of different kinds of gear-cutting machines in one shop should be reduced to a minimum, as otherwise, in shops where gear cutting is done only occasionally, the workman will have to educate himself by studying the machine each time before proceeding with the cutting of the gear. It is believed that in many small shops it would be greatly to the advantage of the manager, instead of cutting the gear in the shop, to utilize standard gears such as are kept in stock by many gear works. Jobbing shops and general repair shops cannot hope to compete in cost of production with shops such as automobile plants, where large numbers of gears of each kind are turned out, as a different type of machine is required for jobbing work. One of the gear-cutting machines encountered, for instance, while excellent for automobile work, would show a loss if less than 25 gears were cut on one adjustment. Again, it would be useless to go to the expense of cutting teeth to the exact mathematical shape required if the gears are made of such inferior material that the teeth will, after a short period of service, wear enough to alter this shape appreciably.

Designing: Strength of Teeth.

No form of tooth other than the involute should ever be used. For ordinary purposes the 14½° involute, which is the standard, is employed, while in exceptional cases, where great strength is required, a 20° involute is used. Diametrical pitch is invariably used, this being the simplest and best. The easiest and best method for designing gears is by the use of the gear slide rule invented by Carl G. Barth, of 1937 N. 33d St., Philadelphia, Pa. This rule, illustrated in Fig. 1, is a convenient method of applying the formula of Wilfred Lewis (as modified by Mr. Barth) to obtain the strength of gear teeth. This formula is as follows: The proper working load on a spur gear is

$$W = \frac{600}{600 + v} s\ p\ f\ y,$$

in which,

v = circumferential velocity of gear in feet per minute.
s = permissible stress on the material at the given speed.
p = circular pitch of gear.
f = face of gear.
y = strength factor found in Lewis's tables for a gear of the number of teeth and of the system under consideration.

DIRECTIONS FOR USE OF SLIDE RULE.—First, in the proper system on the bottom disk, set the rider to coincide with the number of teeth of the gear whose strength is to be found, and then set the intermediate disk (manipulated through the finger slot in the bottom disk), so that the pitch of the gear—diametrical or circular as the case may be—will coincide with the rider thus set, and then tighten the clamping nut at the center.

Next, set the rider to coincide with the face of the gear on the intermediate disk, and then loosen the clamping nut and set the top disk (readily manipulated because of its shape) so that the permissible static stress on the material in the gear will coincide with the rider in this new position, and again tighten the clamping nut.

Finally, set the rider to coincide with the circumferential velocity of the gear on the top disk, and then read off the corresponding proper working load for the gear where the reading on the scale of loads on the bottom disk coincides with the rider in this last position.

With a little care the tightening of the clamping nut after the first setting is readily dispensed with.

EXAMPLE.—What will be a proper working load for a spur gear of the 20° involute system, when it has 40 teeth, 1½ per in. of diameter, 5-in. face, and is made of cast iron whose permissible static stress is 8,000 lbs., and run at a circumferential velocity of 600 ft. per min. This is the example for which the instrument is set in the accompanying illustration, which shows a load of 5,200 lbs.

In regard to the permissible static stress on various materials used for gears, Mr. Lewis recommended 8,000 lbs. for good cast iron and 20,000 lbs. for steel, but as there are so many different grades of the same material and under certain circumstances a much higher stress is permissible than under other circumstances, it has been considered best not to make any special recommendations in connection with this slide rule, and hence a general scale only of permissible stresses has been provided, instead of special marks for various materials.

SAMPLE SPUR GEAR DESIGN.—Problem: A 50-HP. motor revolving at 900 r. p. m., is required to transmit this horsepower to a parallel shaft revolving at 150 r. p. m. The diameter of the motor armature shaft is 3½ ins.

To keep down the size of the larger gear the motor pinion must be as small as practicable. To give enough metal outside the shaft, the pitch diameter of the pinion can scarcely be less than

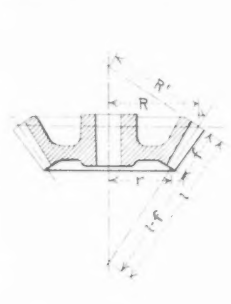


Fig. 2. Diagram of Bevel Gear Showing Radius (R') of Formative Pitch Circle.

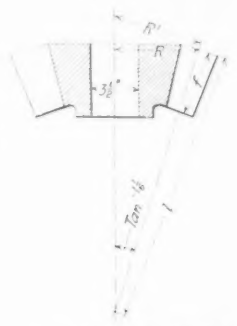


Fig. 3. Trial Sketch of Bevel Pinion to Determine Minimum Possible Pitch Diameter.

7 ins. The corresponding pitch diameter of gear will be $(900 \div 150) \times 7 = 42$ ins. The first step is to take a trial gear and see what horsepower it will transmit, the gear being modified then in the necessary direction to give results approximating more closely to those desired.

For the trial pinion, assume a diametrical pitch of 2, and a face of 4 ins. Then the number of teeth on the pinion will be $7 \times 2 = 14$. Taking up the slide rule, set the rider on 14 teeth; then set the intermediate disk so that the pitch of the gear (2) coincides with the rider thus set. Next, set the rider to coincide with the face of the gear on the intermediate disk, the face being 4 ins.; then set the top disk so that 20,000, the strength of the cast steel of which the pinion is made, is opposite 4. Finally, set the rider to coincide with the circumferential velocity of the pinion on the top disk, this circumferential velocity being $(900 \times \frac{7}{12} \times 3.1416) = 1{,}650$ ft. The corresponding tangential load on the gear in pounds, as read on the bottom disk, is 2,480. The horsepower that the pinion is capable of transmitting is, therefore, $1{,}650 \times 2{,}480 \div 33{,}000 = 124$. This is about right for the pinion, as the motor will be required to deliver 100% over-load for a limited time.

STRENGTH OF BEVEL GEARS.—According to the formula developed by Mr. Lewis, the strength of a bevel gear will be to the strength of the spur gear of the same formative number of teeth, pitch and face as $(l - f)$ is to l, the pitch radius of the corresponding spur gear being R' (see Fig. 2). Referring to the figure, the formative number of teeth of the bevel gear is

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the number of teeth in a spur gear of the Radius R' and of the same pitch as the bevel gear, as the form of the teeth in this gear is the same as that of the teeth in such spur gear. The extreme limit of the ratio $\frac{f}{l}$ recommended by Mr. Lewis is equal to $\frac{1}{3}$. The corresponding value of $\frac{l-f}{l}$ is, therefore, equal to 2/3; or the strength of this bevel gear is 2/3 that of the spur gear of radius R'.

If in the above problem, therefore, it were desired to use bevel gears instead of spur gears, the procedure would be as follows: Lay off the pitch line angle $= \tan^{-1}\frac{150}{900} = \tan^{-1}.167$. Sketch in a trial pinion with this pitch line angle with 3½-in. hole (Fig. 3). The angle is $\theta = 9°30'$. It will be found that R can hardly be less than about 4 ins. $R' \cos\theta = R$; or $R' = \frac{R}{\cos\theta} = \frac{4}{.986} = 4.06$, say 4 ins. Assuming a 4-in. face as before and diametrical pitch of 2, refer to Barth's slide rule, the number of teeth in the pinion being $2 \times 8 = 16$. The circumferential velocity in this case is $900 \times \frac{8}{12} \times 3.1416 = 1{,}880$ ft. per min. Hence (from the slide rule) the tangential load that can be borne by the corresponding spur gear is 2,420 lbs.

$$\frac{R'}{l} = \tan\theta = \frac{1}{6}.$$

$$R' = \frac{l}{6};\ l = 6R' = 24 \text{ ins.}$$

$$\frac{l-f}{l} = \frac{24-4}{24} = \frac{20}{24} = \frac{5}{6}$$

Therefore, the strength of bevel gear is 5/6 the strength of the formative spur gear of radius R', or $5/6 \times 2.420 = 2{,}010$. Then the horsepower it will transmit is

$$\frac{2{,}010 \times 1{,}880}{33{,}000} = 115$$

which is about right.

While considerations of efficiency might suggest the desirability of making gears of cast-iron where the pinions are of steel, the pinion tooth in the above instance getting six times the work of the gear tooth, the fact that a single broken tooth in the gear will necessitate the renewal of a large expensive wheel is a strong argument against using a lower grade of material for the gear than for the pinion.

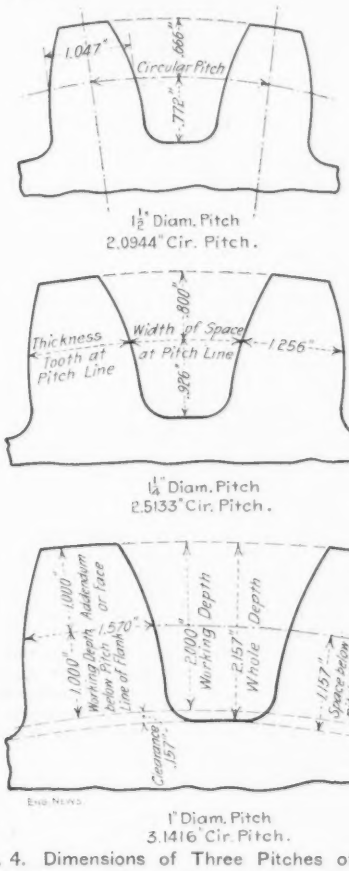
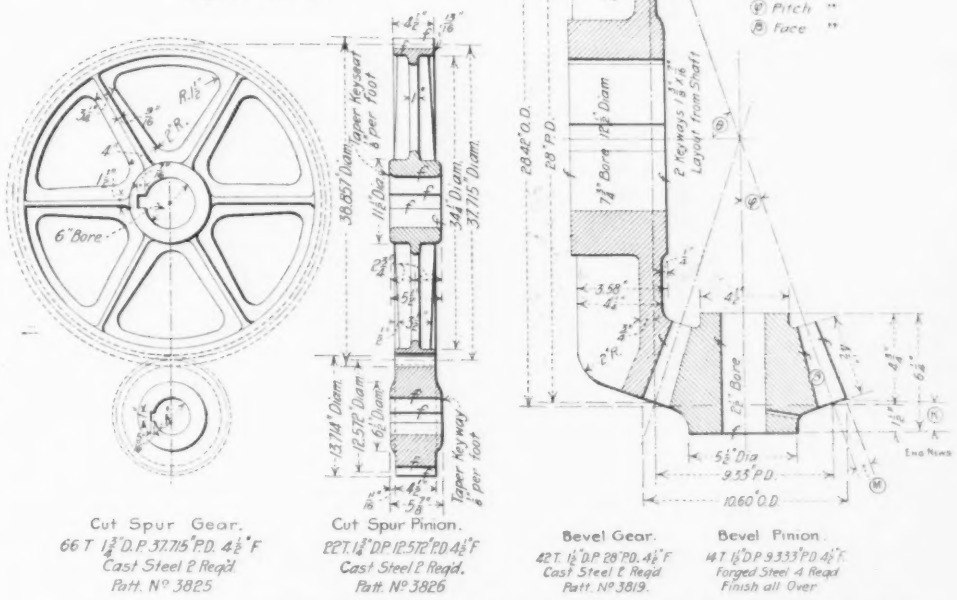


Fig. 4. Dimensions of Three Pitches of Involute Teeth, Showing Where to Apply Measurements Given in Tables I. and II.

Bill of Material				
№	Mat'l	Patt'n	Description	Remarks
2	C. S.	3819	Bevel Gears	Cut
4	F. S.	A	Bevel Gears	"
2	C. S.	3825	Spur Gears	"
2	C. S.	3826	Pinions	"

Fig. 7. Specimen Bill of Material for Gears Shown in Figs. 5 and 6.



FIGS. 5 AND 6. SPECIMEN OF COMPLETE WORKING DRAWINGS FOR SPUR AND BEVEL GEARS.

Drafting.

Fig. 4 shows details of three different diametral pitches. Tables I., II. and III. give necessary information to the draftsman. The diameter increment table, Table III., is used to obtain the outside diameter of bevel gears, also the dimension K on Fig. 6—the "backing" of the bevel pinion.

TABLE I.—DIAMETRAL PITCH: DIMENSIONS OF INVOLUTE TEETH.*

Diametral pitch.	Circular pitch.	Thickness of tooth on pitch line.	Depth to be cut in gear.	Addendum.
½	6.2832	3.1416	4.3142	2.0000
¾	4.1888	2.0944	2.8761	1.3333
1	3.1416	1.5708	2.1571	1.0000
1¼	2.5133	1.2566	1.7257	.8000
1½	2.0944	1.0472	1.4381	.6666
1¾	1.7952	.8976	1.2326	.5714
2	1.5708	.7854	1.0785	.5000
2¼	1.3963	.6981	.9587	.4444
2½	1.2566	.6283	.8628	.4000
2¾	1.1424	.5712	.7844	.3636
3	1.0472	.5236	.7190	.3333
3½	.8976	.4488	.6163	.2857
4	.7854	.3927	.5393	.2500
5	.6283	.3142	.4314	.2000
6	.5236	.2618	.3595	.1666
7	.4488	.2244	.3081	.1429
8	.3927	.1963	.2596	.1250
9	.3491	.1745	.2397	.1111
10	.3142	.1571	.2157	.1000
11	.2856	.1428	.1961	.0909
12	.2618	.1309	.1798	.0833
14	.2244	.1122	.1541	.0714
16	.1963	.0982	.1348	.0625
18	.1745	.0873	.1198	.0555
20	.1571	.0785	.1079	.0500
22	.1428	.0714	.0980	.0455
24	.1309	.0654	.0898	.0417
26	.1208	.0604	.0829	.0385
28	.1122	.0561	.0770	.0357
30	.1047	.0524	.0719	.0333
32	.0982	.0491	.0674	.0312
36	.0873	.0436	.0599	.0278
40	.0785	.0393	.0539	.0250
48	.0654	.0327	.0449	.0208

*See Fig. 4.

The information required on a plan of gears is only that shown on Fig. 5 and 6, for spur and bevel gears respectively. Fig. 6 shows, enclosed in circles, information that is not put on the tracing of bevel gears, but is ordinarily added in red ink on the blueprints. Great care should be exercised to show on the plan only the necessary information, as surplus matter merely tends to obscure the essential. Fig. 7 shows a sample "bill of material." It is never necessary to draw the teeth, except for cast gears which, as noted above, are not recommended. The drawing office should know the capacity of the gear cutting machines in the machine shop in order that the gear designs may be modified, where practicable, in order to bring them within the capacity of the machines available.

Gear-Cutting.

For cutting spur gears a machine of the general type illustrated in Fig. 8 gives satisfaction. The number of such machines, and their capacity, would vary with the amount of gear work the shop is destined to handle. One such machine in every shop should be provided with attach-

TABLE II.—CIRCULAR PITCH: DIMENSIONS OF INVOLUTE TEETH.*

Circular pitch.	Diametral pitch.	Thickness of tooth on pitch line.	Depth to be cut in gear.	Addendum.
6	.5236	3.0000	4.1196	1.9098
5	.6283	2.5000	3.4330	1.5915
4	.7854	2.0000	2.7464	1.2732
3½	.8976	1.7500	2.4031	1.1140
3	1.0472	1.5000	2.0598	.9550
2¾	1.1424	1.3750	1.8882	.8754
2½	1.2566	1.2500	1.7165	.7958
2¼	1.3963	1.1250	1.5449	.7162
2	1.5708	1.0000	1.3732	.6366
1⅞	1.6755	.9375	1.2874	.5968
1¾	1.7952	.8750	1.2016	.5570
1⅝	1.9333	.8125	1.1158	.5173
1½	2.0944	.7500	1.0299	.4775
1⅜	2.2848	.6875	.9441	.4377
1¼	2.5133	.6250	.8583	.3979
1⅛	2.7925	.5625	.7724	.3581
1	3.1416	.5000	.6866	.3183
15/16	3.3510	.4687	.6437	.2984
⅞	3.5904	.4375	.6007	.2785
13/16	3.8666	.4062	.5579	.2586
¾	4.1888	.3750	.5150	.2387
11/16	4.5696	.3437	.4720	.2189
⅝	5.0265	.3125	.4291	.1989
9/16	5.5851	.2812	.3862	.1790
½	6.2832	.2500	.3433	.1592
7/16	7.1808	.2187	.3003	.1393
⅜	8.3776	.1875	.2575	.1194
5/16	10.0531	.1562	.2146	.0995
¼	12.5664	.1250	.1716	.0796
⅛	25.1327	.0625	.0858	.0398
1/16	50.2655	.0312	.0429	.0199

*See Fig. 4.

ments for automatically hobbing worm wheels, rack cutting and internal gear cutting, and special gear cutting. These machines should be entirely automatic. A roughing cut should be taken first in order to save work on the finishing cutter, to increase the life of this cutter and to enable it to cut for a longer period between sharpenings. Cutting spindles usually carry a roughing cutter and finishing cutter at the same time, so that one tooth space is being finished while the one ahead of it is being rough cut. The price of a machine that will cut steel spur gears up to 60 ins. diameter and 16-in. face with 2 diametral pitch, is $1,900 f. o. b. factory, exclusive of motor. The minimum center distance between work and cutter arbor of this machine is 3⅜ ins.

The standard (diametral) pitches of teeth are 2, 2½, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12; 14, 16, 18, 20, 22, 24; 28, 32, 36, 40 and 48. For each pitch eight cutters are required, as shown in table below, or for the 15 pitches, 2 to 20, that a shop doing jobbing work will probably have occasion to use, 120 cutters are necessary:

No. 1 cutter will cut from 135 teeth to a rack.
No. 2 cutter will cut from 55 teeth to 134 teeth.
No. 3 cutter will cut from 35 teeth to 54 teeth.
No. 4 cutter will cut from 26 teeth to 34 teeth.
No. 5 cutter will cut from 21 teeth to 25 teeth.
No. 6 cutter will cut from 17 teeth to 20 teeth.
No. 7 cutter will cut from 14 teeth to 16 teeth.
No. 8 cutter will cut from 12 teeth to 13 teeth.

These cutters are for standard 14½° involute teeth. All gears of the same pitch cut with these cutters are interchangeable. The best design for these cutters is that which permits them to be sharpened by grinding without changing the form of the cutter. These are so shaped that when ground on a radial face they will continue to cut a perfect involute tooth as long as there is anything left of the cutter.

For cutting bevel gears, the automatic bevel gear planer is satisfactory for use in a jobbing plant. In case of a shop where only one machine is desired the 24-in. is probably best for all purposes. This machine cuts involute teeth to correct shape on the copying principle, templates of the involute tooth form being used. For every bevel gear to be cut, three templates are employed—one with a straight surface for roughing cut and two for finishing, one with a convex surface, and one with a concave surface for cutting the two sides of each tooth. These templates are mounted on a revolving holder, so that they can be brought successively into position without removing one to give place to another. With each machine is furnished a complete set of tooth templates, 25 in number, which suffice for cutting all varieties of bevel teeth.

The writer is indebted to the Fawcus Machine Co. of Pittsburg, Pa., for assistance on the most important parts of this article.

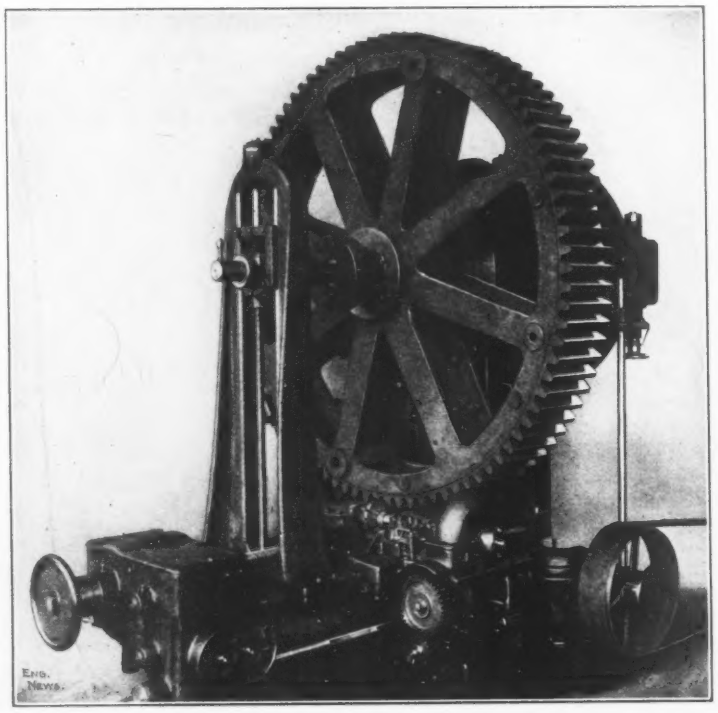


FIG. 8. GEAR-CUTTING MACHINE OF THE TYPE RECOMMENDED BY THE AUTHOR.

(Shown cutting a 90-tooth cast-iron gear with 3-in. circular pitch; outside diameter, 87.86 ins.; face, 12 ins. Total cutting time, roughing and finishing, 7 hrs. 35 mins.; finishing alone, 5 hrs. 15 mins.)

TABLE III.—OUTSIDE DIAMETER INCREMENTS FOR BEVEL GEARS.

RULE.—The ratio being known, to find the outside diameter: Divide figures given in table for large and small gear by the diametral pitch and add proper quotient thus obtained to each pitch diameter.

Ratio.		Gears. Large.	Gears. Small.	Ratio.		Gears. Large.	Gears. Small.	Ratio.		Gears. Large.	Gears. Small.
1.00	1:1	1.41	1.41	1.65	...	1.05	1.70	4.40	...	.45	1.94
1.05	...	1.37	1.42	1.67	5:3	1.03	1.72	4.50	9:2	.44	1.95
1.07	...	1.36	1.43	1.70	...	1.01	1.73	4.60	...	.42	1.95
1.10	...	1.35	1.44	1.75	7:4	.99	1.74	4.80	...	.41	1.96
1.11	10:9	1.34	1.46	1.80	9:5	.97	1.75	5.00	5:1	.39	1.96
1.12	...	1.33	1.46	1.85	...	.95	1.76	5.20	...	.38	1.96
1.13	9:8	1.33	1.47	1.90	...	.93	1.77	5.40	...	.37	1.96
1.14	8:7	1.32	1.49	1.95	...	.91	1.78	5.60	...	.36	1.97
1.15	...	1.31	1.50	2.00	2:1	.89	1.79	5.80	...	.34	1.97
1.16	...	1.30	1.51	2.10	...	.87	1.80	6.00	6:1	.33	1.97
1.17	7:6	1.30	1.52	2.20	...	.84	1.81	6.20	...	.32	1.97
1.18	...	1.29	1.53	2.25	9:4	.82	1.82	6.40	...	.31	1.97
1.19	...	1.28	1.53	2.30	...	.80	1.83	6.60	...	.30	1.97
1.20	6:5	1.28	1.54	2.33	7:3	.78	1.84	6.80	...	.29	1.98
1.23	...	1.27	1.55	2.40	...	.76	1.85	7.00	7:1	.28	1.98
1.25	5:4	1.25	1.56	2.50	5:2	.75	1.86	7.20	...	.27	1.98
1.27	...	1.25	1.57	2.60	...	.73	1.86	7.40	...	.27	1.98
1.29	9:7	1.24	1.58	2.67	8:3	.71	1.87	7.60	...	.26	1.98
1.30	...	1.22	1.59	2.70	...	.69	1.87	7.80	...	.26	1.98
1.33	4:3	1.20	1.60	2.80	...	.67	1.88	8.00	8:1	.25	1.98
1.35	...	1.18	1.61	2.90	...	.65	1.89	8.20	...	.24	1.98
1.37	...	1.17	1.61	3.00	3:1	.63	1.91	8.40	...	.24	1.98
1.40	7:5	1.16	1.62	3.20	...	.60	1.92	8.60	...	.23	1.98
1.43	10:7	1.15	1.63	3.33	...	.58	1.92	8.80	...	.23	1.98
1.45	...	1.13	1.65	3.40	...	.56	1.92	9.00	9:1	.22	1.99
1.50	3:2	1.11	1.66	3.50	7:2	.54	1.93	9.20	...	.22	1.99
1.53	...	1.10	1.67	3.60	...	.52	1.93	9.40	...	.21	1.99
1.55	...	1.09	1.67	3.80	...	.50	1.94	9.60	...	.21	2.00
1.58	...	1.08	1.68	4.00	4:1	.49	1.94	9.80	...	.20	2.00
1.60	8:5	1.07	1.68	4.20	...	.47	1.94	10.00	10:1	.20	2.00

NOTE: To be used only for bevel gears with axes at 90°.

EXAMPLE: Large gear: 30" P. D., 3 D. P., 90 T., outside diam. = X_1. Small gear: 15" P. D., 3 D. P., 45 T., outside diam. = X_2. Ratio = 2:1.

$$X_1 = 30 + \frac{.89}{3} = 30.296. \qquad X_2 = 15 + \frac{1.79}{3} = 15.596.$$

To get the backing K in Fig. 6: Ratio = 42 ÷ 14 = 3; D. P. = 1½. .63 ÷ 1½ = .42; .42 ÷ 2 = .21; 1½ ins. + .21-in. = 1.71 ins. = K.

The Newhall Tunnel, Los Angeles County, California.*

A great impediment in road travel between Los Angeles and northern sections in the San Fernando Valley has been eliminated by the construction of a tunnel, which is one of the most notable examples of road engineering in the State. The old pass, known as Newhall or Fremont Pass, was used as a trail prior to 1860, when it was made into a highway as the continuation of San Fernando Road. It had a 23% grade and has been noted as being the most precipitous portion of traveled road in the county and was to many types of vehicles impassable. The ascent has been the scene of many disasters.

Largely through the efforts of the Los Angeles County Good Roads Association, this tunnel, shown in the accompanying cut, has been constructed at a cost of $66,000. It reduces the grade to 6%, and is an essential link in the good roads system of Los Angeles.

The tunnel is 200 ft. below the surface at this point; it is 435 ft. long and 20 ft. wide. The lining is of concrete, finished with a coat of white plaster, thus affording the greatest amount of light possible. Provision is made to use current from the Aqueduct, when it is available at this point, for electric lighting. Although waterproofing was called for in the specifications, it has been deemed unnecessary, owing to the extreme dryness of the rock formation. A system of storm-water drainage is to be installed. The approaches are cut through rock and shale, and retaining walls will later be constructed to prevent shale slides.

The Newhall Tunnel, Los Angeles County, Cal.

About a mile of new road was constructed in the approaches. The grade on the southern approach will be reconstructed to the end of the Aqueduct, following the west side of the Southern Pacific R. R. and crossing the tracks at Tunnel Station by means of a concrete viaduct. This route will permit the abolishment of three dangerous grade crossings.

The Newhall Tunnel has been recently opened to public travel. It was constructed by Mr. E. E. Shaffer, under the supervision of Mr. A. E. Loder, Chief Engineer for the Highway Commission.

A GAS-HOLDER COLLAPSE in Hamburg, Germany, on Dec. 7, 1909, (see note in Eng. News, Dec. 9, 1909, p. 657, "An Explosion in a Gas-Retort House") has been found to be chargeable to failure of the columns supporting the floor of the holder. Prof. Krohn and Prof. Müller-Breslau reported on the accident, for the city and the company that built the holder, respectively. Prof. Krohn concludes that the floor columns failed when a slight rise of gas-pressure occurred while the holder was filling. In his opinion the floor columns, which were made up of two rolled shapes connected by tie-plates and had been proportioned for one-fourth the Euler buckling load, had only a low factor of safety under their normal load, and only a small excess of gas-pressure was required to bring about their failure. An article by Prof. Oder in "Zentralblatt der Bauverwaltung" of April 12, 1911, in which the above facts are stated, argues against the unlimited use of the Euler formula for proportioning columns.

*From information furnished by L. R. W. Allison, Los Angeles, Cal.

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The difference between arbitrary and rational methods of establishing and enforcing standards was illustrated at the National Conference on City Planning, held at Philadelphia, last week. A contrast was there presented between setting up a width of 50 or 60 or 80 ft. for all streets, regardless of their character and use, and adapting street widths to their probable uses as minor or major residence or business streets, and minor, intermediate and major through-traffic streets.

In place of arbitrary widths, it was agreed (see report of conference and particularly the paper by Mr. John Nolen, elsewhere in this issue) that street widths and the apportionment of space between roadway, sidewalks and planting strips (grass and trees) should properly be determined on a standard-unit basis: number of lines of vehicles, pedestrians and rows of trees to be provided for in each of the three main divisions of the street.

In discussing unit widths of roadways the members of the conference concerned themselves wholly with a standard allowance for vehicle widths and the number of rows of vehicles abreast for which provision should be made. Obviously, in the actual study of a given street-width problem it would be necessary to take speed into account. This, in turn, would be governed more or less by the character of the street surface, the grade, the alinement, character of traffic on intersecting streets, and presence or absence of surface railways. Of material importance, also, would be the character of the traffic on the street being designed, notably whether business or pleasure, and whether horse-drawn or motor-drawn.

The whole subject brings up anew the almost universal lack of adequate street-traffic censuses. Of course, a traffic census cannot be taken for a street not yet opened, but street traffic counts are essential to the extensive replanning of street systems already demanded and in part under way, and full knowledge of the volume of existing traffic on streets of different classes in various cities would be of great assistance in forecasting the volume and character of traffic on proposed streets. We hardly need add that all this information is quite as essential for the proper selection of street pavements as for the determination of street widths.

Many of the participants in the conference spoke of the desirability of so choosing the total width of streets and apportioning it to the various sub-divisions as to facilitate readjustments in the future. Mr. Haldeman, of Philadelphia, happily characterized a street so designed as an "elastic street." Such a street might have a two unit-vehicle width at the start, grass plots inside the curb line and narrow sidewalks, and ultimately the grass plots might be narrowed and the roadway, and perhaps the sidewalks as well, widened to provide for an increased traffic, or there might be two roadways, with a grass plot between.

We say grass plot rather than tree-planting strip, because if trees were once established between the curb and the sidewalk the elastic limit of the street would soon be almost if not quite lost, as every one knows who has ever witnessed a campaign for removing street shade trees. The difficulty can be obviated, in many cases, by planting street trees on the lawn side rather than the curb side of the footway.

What we have said thus far regarding the elastic street relates primarily to residence streets which have lawns between the houses and sidewalks. Where the whole street is given over to paved roadway and sidewalks its only elasticity lies in a redistribution of the sidewalks and roadways; but in laying out new districts this condition would not often arise.

The whole subject of street widths and their subdivision deserves and is bound to have far more attention in the future than has been given it in the past. We are pleased to state that a book entitled "Street Widths in Relation to City Planning," by Mr. Charles Mulford Robinson, is now well on towards completion, and will soon be definitely announced.

The experiences of a considerable number of cities which have laid steel water-supply mains in the last 20 years, and recent discussions on the life of such conduits, appear to have led the Trustees of the Portland Water District (Me.) to decide to spend $91,000 additional for a cast-iron water-supply main instead of following the recommendation of its engineer and adopting steel.

It appears from the recently published report of the Portland Water District for the calendar year 1910 that a new conduit is to be laid from Sebago Lake to Portland, some 15 miles, in order to bring in a possible additional 18,000,000 gals. of water per day, or double the capacity of the existing wrought-iron and cement mains.

In the summer of 1910, bids were invited for a 48-in. steel main and for a 42-in. cast-iron main (see tabulated list of bids, Construction News Supplement for Sept. 22, 1910, p. 132). The lowest bid for supplying and laying the steel main was $593,325, and the lowest combined bid for furnishing and laying cast-iron pipe and specials was $684,219, thus making a difference of approximately $91,000 in favor of a steel main. After recounting these facts, the report already mentioned goes on to say:

> This brought the question of the comparative merits of cast-iron and steel pipes squarely before the Trustees.
>
> The Trustees found, upon examination of the history of steel mains already installed, that steel pipe corroded much more rapidly than cast-iron and the expense of maintenance was much greater, also that the life of cast-iron pipe was generally conceded to be one hundred years, while no one estimated steel pipe at over forty years.
>
> Meanwhile protests against the use of steel pipe were pouring in upon the Trustees from influential citizens of Portland who were interested in the question and had given it careful study, and it soon became apparent that public sentiment was almost unanimously in favor of cast-iron pipe.
>
> Mr. Allen Hazen, the consulting engineer of the district, advised the use of steel pipe and the acceptance of the bid of T. A. Gillespie & Co. He was confident that the improvements made in the coating of steel pipe of recent construction would overcome the defects found in the old mains. Believing, however, that the Portland Water District should confine itself to approved types of construction and refrain from experimenting, the Trustees, after careful consideration of the matter, voted unanimously to construct the main of cast-iron pipe. * * *

It is interesting to note that the Trustees of the Water District seem to have given less weight to the recommendations of their consulting engineer than to "protests" made by "influential citizens" who had given the subject "careful study." Possibly no other course was logically open to them, as servants of the district, if they were satisfied that "public sentiment was almost unanimously in favor of cast-iron pipe."

It may well be questioned, however, whether the public sentiment in favor of the more expensive construction was well advised. If the $91,000 saved by installing the cheaper conduit be invested in a sinking fund and allowed to accumulate at 4% interest, it will amount at the end of 40 years, which has been assumed as the life of the steel pipe, to $436,800. This will not equal the present cost of the steel main, it is true, as it should do to make the steel conduit as cheap as the cast iron on an accounting basis; but the difference is only $150,000, and it may be worth as the cast-iron on an accounting basis; but the lay some other type of conduit which may by that time be developed of greater cheapness and durability, or perhaps leading to some other source of supply.

There are so many doubtful and uncertain factors in figuring upon events 40 or 50 or 100 years hence, that it is seldom safe to base any large excess of present outlay on savings to be made then.

A very important sidelight upon the significance of the recent Supreme Court decision in the Standard Oil Case is furnished by the suit begun by the Government on May 19 against various associations of lumber dealers in New England and the Middle States. The chief object of these organizations is to compel the purchaser of lumber to buy only of the retail dealer and prevent him dealing direct with the lumber manufacturer or the wholesale lumber dealer. The organizations are, in fact, typical of those existing in many other lines of trade which have for their main object the limitation of competition, by perpetuating the power of the "middle man" and preventing consumers buying direct from the wholesaler or the manufacturer and retail dealers from going over the heads of the jobber or wholesaler.

The Supreme Court has ruled that the Sherman Law is not to be interpreted as forbidding contracts where "restraint of trade," or in other words restriction of competition, may be an incidental effect and the main purpose of the contract is to effect economy in production or distribution. The Sherman Law is not, for example, to prevent formation of large organizations where such organizations are necessary to effect economy.

But where the *chief* purpose of a contract or an organization is to limit competition, there is nothing in the Supreme Court decision to indicate that any such contracts can be considered reasonable.

Of course, it is well known that organizations to control both wholesale and retail trade are common in almost every line of business. Every engineer who has had to do purchasing on a large scale for construction work is well aware of the power of these associations and of their important influence in limiting competition and raising prices. That all such associations are now declared to be unlawful and that those engaged in them are conspiring to injure the community and are in peril of punishment may be reasonably concluded from the Supreme Court's decision.

The Atlantic City drawbridge disaster of 1906 on a branch of the Pennsylvania Railroad was long an object lesson as to the inherent danger of a drawbridge having its movable rails not interlocked with the signals governing the movement of trains over the bridge. Doubtless the warning given by that accident has been of great influence in securing safe construction on many railway drawbridges since that time. That there are some who are still ignorant of such object lessons and who will run risks of disaster in the face of such warnings is shown by the Accident Bulletin of the Interstate Commerce Commission

for the last three months of 1910. An accident is there reported very similar to that which occurred at Atlantic City five years ago, although by good fortune only one life was lost instead of fifty. It appears from the report that a passenger train stopped on the approach until the bridge tender gave a hand signal to proceed. This man, however, did not inspect the rail connections before giving the signal and (as at the Atlantic City bridge) one of the movable rails had failed to drop into place and rested upon the top of the adjacent rail. The engine and tender were derailed and fell into the river; the engineman was drowned and the fireman injured. Investigation showed that there was no interlocking of bridge machinery and signals, and not even the simplest mechanism in the form of a rail lift or lock. It is true that the bridge tender (a youth of 22) was negligent; but such negligence is bound to occur more or less often as everyone knows. The most serious negligence was the failure to instal apparatus which would reduce the vigilance and judgment required of the bridge tender to the least possible amount.

We discussed in our last week's issue plans for the introduction of an emergency water-supply to guard against the danger of a water famine in New York City. There are many cities in the Eastern and Middle States which are in greater danger of water shortage during the coming season, than New York City, unless the present deficiency in rainfall should be made up during June and July.

All through New England, and to a large extent in New York and states farther south, the ground water level is very low; streams are already at a stage usual in summer droughts, and water storage reservoirs which are usually full at this time of the year have already been heavily drawn upon. Fortunately, in a city of moderate size the introduction of an emergency supply is much simpler than in the great city of New York, with its enormous consumption of water. In a number of New England cities it is reported that plans are already under way to drive artesian wells, from which additional water can be secured in case of necessity.

In very many cases it is possible for a city to secure an emergency supply from river water which is too polluted for use under ordinary circumstances. The process of water sterilization with hypochlorite of lime is of exceedingly great value in making it possible to introduce such polluted supplies for emergency use, without running serious danger of spreading disease. The introduction of hypochlorite into the supply as it is pumped ensures thorough mixture in its passage through the pipe line.

Of course, every one hopes, on the old rule that one extreme follows another, that the shortage of rainfall which has prevailed now for nearly a year may be succeeded by a wet summer and fall in place of the droughts that have marked the last four years. Since no one can be certain of such good fortune, however, it is well for waterworks superintendents to have definite plans prepared in advance for securing and erecting emergency pumping plants, pipe lines, and any other necessary apparatus, which may be required if the worst comes.

The danger of water famine in New York City, reviewed in these columns last week, has been under active discussion in the New York daily papers since and has attracted especially wide attention because of the prolongation of the unusual spring drought.

The public anxiety which has been aroused over the water-supply situation has had the excellent effect of bringing a powerful public sentiment to bear in favor of a $100,000 appropriation by the Board of Aldermen to provide a large additional force of waste-prevention inspectors. While the work in this direction already done has reduced the per capita consumption already to a figure surprisingly low, considering all the conditions, it will doubtless be possible to make some further reduction, and every effort to that end is to be commended.

The recommendation made in these columns last week that an engineering pumping plant and pipe line be built in the shortest possible time to divert the flow of the Ten Mile River into the headwaters of the Croton, has been heartily commended by some of the principal New York journals but has been received with more or less incredulity and "inertia" in official circles. It is always easier to find obstacles in the way of doing things than to get out and hustle and overcome the obstacles.

So far as the work of engineering construction is concerned, the principal objection raised is that it would take too long to build the pumping station and pipe line. In answer to this we are able to state that two responsible concerns, with large plants and organizations, stand ready to built the pumping station and pipe line complete and will have water from the Ten Mile River flowing into the Croton storage reservoirs within 90 days from the time of signing the contract.

It is said, however, that in time of extreme drought, the natural flow in Ten Mile River might fall below the 50,000,000 gallons per day we have assumed. That is admitted, but is no real argument against the proposed scheme. Let us get what we can from the Ten Mile River even though for two or even three of the dryest months the flow is somewhat less than the capacity of the proposed pumping station and pipe line. We have to deal with a peril that will continue not only this year but next year and until the additional supply from the Catskills can be brought down as far as the Croton reservoir.

To make clear the value of the proposed Ten Mile River additional supply, suppose that the City of New York had been wise enough and far-sighted enough to heed the warnings of the expert engineers sounded years ago, and bring the Ten Mile River additional supply into the Croton watershed even so recently as a year ago. Had that been done, New York would have to-day something like 15,000 million gallons additional supply in its storage reservoirs available to tide her over the drought period, or enough to supply the city for about 45 days. Admittedly the Ten Mile River ought to have been utilized a year or two years ago; but that is no reason why it should not be taken now.

But to most of the objectors the legal difficulties are the principal thing in the way. What are these legal difficulties? Who would suffer any material injury if New York should take the proposed amount from the Ten Mile River? The first legal difficulty in the way is a "fool" law—we use the term advisedly—passed by the New York legislature eight or ten years ago, forbidding New York City to take for its needs any water from Dutchess County. This law was passed with reference to streams flowing into the Hudson River and to permanent appropriation of these streams. The use of Ten Mile River water by New York would not injure the residents of Dutchess County at all, for a mile or two below the site of the proposed pumping station the river flows across the border into Connecticut and empties into the Housatonic. There should be no voice raised in the New York legislature, therefore, against an act permitting New York to take water from Dutchess County for its urgent necessity until the Catskill water can be brought down.

And now who would be injured in Connecticut by the proposed appropriation and what would the injury amount to?

The sole extent of the injury would be that during the low-water months of the year, say for perhaps four to seven months, the flow of water in the Housatonic below the Ten Mile outlet would be reduced by *about one-eighth*.

We have not the data at hand as to present development of water-power on the lower Housatonic; but at the time Mr. John R. Freeman recommended that stream as a source of water-supply for New York, the total power developed that would be affected by the proposed diversion did not exceed 2,500 HP. One-eighth of this is 312 HP. Suppose the actual power lost by the mill-owners were three times as much, or a thousand horsepower. How trifling is the value of such an amount of power compared with the value of the water to relieve the necessitous emergency of a great city! New York could well afford to pay double, treble, ten times the actual damage to the mill-owners rather than forego the use of the water.

The offer by the city to amply compensate the mill-owners for all damages due to diversion ought to be sufficient to prevent any interference with the work by injunction on the part of the Federal courts.

It is not a new thing by any means for a state to appropriate water within its boundaries to the detriment of residents on the lower course of the river in another state. Colorado irrigators years ago used up water which had been flowing across the boundary into Kansas; but the Supreme Court of the United States refused to interfere, and the Kansas riparian owners received no damages. In Illinois, the city of Chicago uses the Illinois River to carry off its sewage; and the Federal Courts refused the petition of St. Louis to have the pollution stopped.

In Massachusetts, the Nashua River, which flows into New Hampshire, is used for the water-supply of Boston, and the Blackstone River, which flows into Rhode Island, for the supply of Worcester. Of course, the right of riparian owners to damages where water is diverted is unquestioned in the Eastern States, and would not be questioned by New York City.

We do not at all accept as correct the declaration that the legal difficulties in the way of utilizing the Ten Mile River are insurmountable. If it is indeed true that the law governing water rights is so seriously at variance with public necessity, then it is high time that some such radical reform of the law was undertaken in the East as has been put in force in some of the progressive states of the West.

Why Is Europe in Advance of America in Pioneer Inventions?

Everybody is familiar with the claim that American inventors, engineers and manufacturers lead the world. A vast amount of boasting has been done about American ingenuity and originality and enterprise. If this claim were well-founded, it would be indeed matter for national pride; and a quarter century or more ago such a claim had a good deal to justify it. There are a number of fields of invention and manufacture in which the pioneer work was done by Americans and in which the statistics of exports still testify to our high standing.

But when one views the whole field of engineering and industry and particularly the progress of the past twenty-five years, it is rather humiliating to confess that instead of being in the lead the United States is lagging far in the rear.

Take for example the advances made in iron and steel metallurgy during the past twenty-five years. Some original contributions have been made to the art by American inventors in that time, of course; but the great advances which have been made have almost all originated abroad. We are to-day something like five years behind Germany in iron and steel metallurgy, and such innovations as are being introduced by our iron and steel manufacturers are most of them merely following the lead set by foreigners years ago.

We do not believe this is because American engineers are any less ingenious or original than those of Europe, though they may indeed be deficient in training and scientific education compared with those of Germany. We believe the main cause is the wholesale consolidation which has taken place in American industry. A huge organization is too clumsy to take up the development of an original idea. With the market closely controlled and certain profits by following standard methods, those who control our trusts do not want the bother of developing anything new.

We instance metallurgy only by way of illustration. There are plenty of other fields of industry where exactly the same condition exists. We are building the same machines and using the same methods as a dozen years ago, and the real advances in the art are being made by European inventors and manufacturers.

Those "effete nations of Europe" actually appear to take a certain pride in doing *new* things that are worth while. Original work by engineers and designers is encouraged and rewarded. In some cases American manufacturers take up these foreign inventions after they have been developed on the other side of the water, and after four or five years the new improvement begins to be introduced here. In other cases, a dozen years or more elapse before any American has enterprise enough to introduce here what has been proved to be excellent on the other side of the ocean.

It would be easy to cite fifty or a hundred important inventions of the past quarter century which have originated in Europe and have come into extended industrial use there and which we have either merely copied or in some instances almost ignored here.

A notable illustration of this lack of originality in present day American industry is the development of the internal combustion engine. There is no doubt that the application of this type of prime mover to a wide range of uses has been the most important development in mechanical engineering of the past twenty-five years; but the original work in this field has almost all been done abroad. We have merely copied the European inventions. Of course, there are some few meritorious details of design which have been worked out by Americans, but so far as we are able to recall, all the really notable advances in the field of gas and oil engines from the beginning have been made in Europe.

Take, for example, the Diesel engine. Invented nearly a score of years ago, by one of the most eminent of German engineers, it is to-day so little used in the United States as to be practically unknown. In Europe, on the contrary, it is to-day attracting more attention than any other prime mover. It has the highest economy in the conversion of fuel into work of any known type of engine. What is much more important, however, is the fact that it can use as fuel the cheapest grade of crude oil.

It has been said that the reason why America ignored the Diesel engine was, first, that coal was so cheap here that the oil engine could not compete with the steam engine and, second, that gasoline was so cheap that there was no market for the crude oil engine. It would be a keener and more accurate criticism to say that American extravagance, carelessness and prejudice against complications in machinery has prevented us from gaining the economies which might have been made had the Diesel engine found a foothold here.

With internal combustion engines of large size, the cost of fuel becomes a very important matter when gasoline, or even natural gas is used. With the enormous stores of crude oil available everywhere in the United States to-day, at very low cost, there can be little doubt that we are losing as a nation hundreds of thousands, if not millions, of dollars by ignoring this important development in mechanical engineering.

We give much space in this issue to an important paper, read at the recent meeting of the Institution of Naval Architects in London, summarizing recent development in the application of the Diesel engine to ship propulsion. Enormous strides have been made in this field within the past two years. Diesel oil engines are now being fitted to ocean vessels of large size. Ship and engine builders in England and on the continent are industriously at work in this field. Dr. Diesel, at the London meeting, declared that Diesel marine engines could produce a horsepower with one-fifth or one-sixth of the weight of fuel required for a steam engine. The enormous importance of such a reduction in the fuel supply, and resultant increase in cargo capacity, is evident to any one. From a naval point of view, also, it is pointed out as among the possibilities of the near future that a battleship may yet be built for a European power which will be able to sail around the world and home again without taking on fuel once.

It may be said that the ship-building industry is so small and unimportant here, compared with what it is in England or Germany, that these things are not important to us. On the other hand, it is a fact that the motor-boat, not only for pleasure use, but for commercial use, is being built in enormous quantities in the United States. The advantages of a machine which can dispense with the danger inseparable from the use of gasoline on vessels, and which can use crude oil costing a dollar or less a barrel instead of gasoline at 10 to 15 cts. a gallon, ought to be sufficient to awaken some of our American manufacturers to the opportunities for enterprise in this field.

LETTERS TO THE EDITOR.

Forest Fires of 1910 in the Northwest.

Sir: Those who have not actually seen the path of destruction left by the forest fires of 1910 in Montana and Idaho can not begin to realize how tremendous and devastating they were.

The forests in Montana and Idaho which suffered most severely were the Coeur d'Alene and Clearwater National forests, the Kanisu, Lolo, Flathead, Bitter Root, Kootenai, Cabinet, Pend d'Oreille and Blackfeet.

TIMBER BLOWN DOWN AND FIRE SWEPT ON EAST FORK OF ST. JOE RIVER.

(Note the evidence of the storm's rotary motion in the fallen timber.)

The timber burned was mostly white pine, spruce, cedar, red and white fir with some lodge pole and hemlock. The greatest loss was from white pine.

On the Coeur d'Alene National Forest approximately 2½ billion ft. of timber were burned and the area covered was about 640,000 acres. The Clearwater National Forest suffered even greater losses.

Burned Cedar Tree Trunks, 4 to 10-ft. in Diameter on North Fork of St. Joe River.

The approximate loss to the entire Coeur d'Alene National Forest was $11,500,000, which sum includes the loss of timber and reproduction only. The losses to property were very great, Wallace, Idaho, sustaining a loss of $350,000. Seventy-nine lives were lost in fighting the fires.

One fire at the headwaters of the St. Joe River burned over an area of 400 square miles. In some places the fire reached such a fury that the cyclonic rush of heated air literally mowed down acres of trees from 2 to 4 ft. in diameter. The spiral path of the storm can be easily traced by the direction of the fallen trunks. This will be noted in the accompanying photograph. It is not an unusual sight to see cedar trees from 4 to 10 ft. in diameter forming partially burned heaps 20 ft. or more in height.

As it is popularly believed that many if not most of our destructive forest fires originate from the carelessness of campers, it is interesting to learn that of 275 reported fires in the Coeur d'Alene National Forest, 65% were caused by locomotives, 6% by lightning and 29% from other causes.

I am indebted for the above information and accompanying photographs to Mr. G. B. Halm, Assistant Forest Ranger, of Wallace, Idaho, who, with a party of 80 men, narrowly escaped death in the great fire of Aug. 20, 1910.

Albert A. Northrop, Assoc. M. Am. Soc. C. E.

Sumner, Washington, April 14, 1911.

The Proper Treatment of Creosoted Wood Blocks for Paving.

Sir: I note with interest an article entitled "Notes on Creosoted Wood-Block Pavement" by Mr. Paul Evans Green in your issue of April 20. There are a great many points in this article which are well taken, especially those concerning the "Character of Work During Construction," "Inspection," etc.

Failure with creosoted wood-block pavement is traceable more to lack of proper attention during time of treatment than anything else. Failure is expensive, as shown in Mr. Greene's article, but in a great many instances no attention is paid whatever by the purchasers to see that they are getting treated blocks as called for in their specifications.

Specifications are of no use unless lived up to. It seems to me that the success of wood-block pavement will only come when the purchasers realize that they are buying an expensive article and, in so doing, must make it a point to see that they are getting the value supposed. The contracts are very often turned over to unscrupulous commercial concerns for treatment. In some instances there is no inspection whatever; in other instances where inspectors are employed, they are wholly unqualified for the position and are onlly able to judge, so far as quality is concerned, that the blocks are black and therefore are creosoted. The result is that after a very short time the pavement is condemned for no other reason than that it failed.

This loose practice is a great mistake. If cities are going to expend large sums for creosoted-block pavements, for their own protection they must have some

competent inspector to look after the treating; he must be a man who is capable of going into every detail of the process, to see to the proper selection of the blocks, to follow the process of treatment through being able to judge when the blocks are properly seasoned, to see that the full amount of creosote required by specifications is injected and that it is of the proper quality. When this is done, instead of having a block pavement which will last six or seven years under heavy traffic as stated in Mr. Greene's article, the pavement should last for at least 20 years, judging from creosoted blocks which are now in existence and in good condition in Galveston and New Orleans, and which have been under constant traffic for 40 years.

I was recently engaged by a purchaser of creosoted blocks to look into the condition of treated material being obtained from a commercial plant. The conditions I found there were appalling. The exterior surface of the wood was burned to a crisp, the interior was wet, and only 9 lbs. of creosote per cubic foot was injected instead of 12 lbs. as required in the specifications. It is just such instances as the above that discourages the use of a material which should stand at the front unexcelled, if the proper care and attention were given the preparation.

Frank D. Beal,
Consulting Timber Preserving Eng.
404 Central Bldg., Seattle, April 26, 1911.

Two Ways of Transporting Earth.

Sir: I am enclosing herewith two pictures taken by myself on the recent trip of the American Society of Civil Engineers to Panama, which illustrate two extreme methods of transporting earth seen during the trip. The first shows the "Jamaica" way of loading a basket

The "Over Head" Way.

The "Pipe Line" Way.

TWO WAYS OF MOVING EARTH.

with the hands and carrying it on a native's head to its destination. The other shows a pipe line delivering material on the core of the Gatun earth dam on the Panama Canal.

Very truly, G. W. Rice.
Lakeview, Oregon, April 20, 1911.

More Concerning Efficiency Engineering.

Sir: There has lately been a great deal of discussion in the scientific press on the subject of Efficiency Engineering and the Taylor system of Scientific Management. Too often the terms are used as synonymous. As a matter of fact, while the Taylor system is pre-eminently one of efficiency engineering, efficiency engineering is not necessarily the Taylor system. There are many practicing efficiency engineers (and the writer is one of them) who find that the opportunities of successfully installing the Taylor system are infrequent indeed, compared with the opportunities in which efficiency methods may be utilized without recourse to that system. The results are not as far-reaching as those obtained by the Taylor system, but they are immediate, and considering the amount of money expended, are usually surprisingly effectual.

The average person, engineer or otherwise, has no conception of the amount of time and money actually being wasted to-day in all lines of manufacturing industry, wastes that may be entirely obviated by the purely physical means of changing the equipment and the systems of operation employed in any particular case. This is not utilizing the Taylor system, but it is none the less efficiency engineering. I know of a large plant, producing a staple building material, which used mine seepage water for its three boilers. Every two weeks one boiler had to be shut down, and two wheelbarrow loads of scale scraped out, which took two men a full day to accomplish. Once a year the entire plant was shut down for one week and the three boilers fitted with new tubes. Adjacent to this plant and using the same seepage water for its boilers was an allied concern, which, however, installed an apparatus for purifying this water by precipitation, incidentally heating their feed-water. This boiler plant was never shut down, except for inspection, and the only work required was for one man to spend a couple of hours each week in removing the shelf from the purifier and knocking the scale off. That was efficiency engineering.

A small terra cotta plant compelled its 40-ct. molders to pick up their own clay from the floor and, after finishing the molding, carry it across the room and deposit it on the floor again. Stop-watch observations showed that only one-quarter of the time was actually employed in molding by these high-priced men. Laborers at 20 cts. were employed to do the carrying, and the 40-ct. molders kept busy at molding, increasing the output four times and at greatly reduced cost per unit. This was efficiency engineering.

A factory in this city, making a food product, had ten hand-operated machines, and was considering the purchase of two big automatic machines to increase the output. Stop-watch observations showed that it required less than a minute to run one box of the product through the machine and start the next box, the operators working easily. For ten machines this would mean 4,800 boxes per 8-hr. day, and, allowing 25% for unavoidable delays (a most liberal allowance), the daily output of this product should have been about 3,600 boxes. Yet the actual average output attained was only 817 boxes. The system was entirely readjusted, so that the machine operators were kept busy at their machines instead of hunting up stock, etc., and the output immediately increased more than five times. This was efficiency engineering. And yet the manager had been considering installing additional machines!

Now, what I wish to emphasize is the fact that thousands and thousands of dollars can be saved in our great cities by just such efficiency methods as the above, entirely ignoring the Taylor system of functional foremen, high-speed work, high-class help and high cost for installation of system. The writer is a sincere admirer of Mr. Taylor and his really wonderful work in this line; but (while still having an open mind on the subject) I doubt whether it would be good policy to attempt to install his system in the majority of smaller concerns which go to make New York the first manufacturing city of this country. Disregarding the so-called factories, which are really sweat-shops, there are thousands of concerns doing a business of from $50,000 to $2,000,000 per year, which have been handed down from father to son, which have never deemed it necessary to employ an engineer permanently, and therefore dispense with one entirely, and which have neither the money to spend on any costly installation nor the inclination to spend it. The result of my observation is that nearly every one of these concerns could be helped by an intelligent application of efficiency principles, with the expenditure of little money, and with surprising results. This is a side of efficiency engineering which (though necessarily a part of Taylor's system) is lost sight of in the general discussion and labor-union agitation against "speeding up." The danger is that in antagonizing the Taylor system as a whole, the labor unions will despoil this other aspect of efficiency engineering which increases production and decreases costs by enabling the workmen to "work easy" instead of making him work hard.

George F. Miles.
108 Worth St., New York City,
May 13, 1911.

The Prevention of Corrosion of Iron.

Sir—In the issue of your valuable journal of May 11, 1911, you print an article by Mr. A. H. Sabin on the rusting of iron, in which he takes occasion to attack not only the electrolytic explanation of the corrosion of iron, but also the general explanation of paint protection which is based on the investigations of a number of independent experimenters in this country and in Europe, who have devoted years of patient research to the subject.

Mr. Sabin shows himself to be a reactionary of a very pronounced type, and appears to be unalterably opposed to any sort of scientific contribution to paint technology, particularly when the scientific contribution fails to coincide with certain preconceived ideas and the business policy of certain special interests. Speaking of the paint problem, Mr. Sabin does not hesitate to say:

> The so-called electrolytic theory of corrosion has nothing to do with it, nor has it very much to do with the general problem of preventing rusting.

This is a broad statement, to say the least, and makes the issue very clear between Mr. Sabin, who has never made an important contribution to the investigation of corrosion problems, on the one hand, and the numerous publications of a band of trained investigators in this country and Europe, on the other hand.

Mr. Sabin's attitude of mind is not unlike that of the farmer's boy who was asked how many legs the old cow would have if he called the tail an extra leg. The boy reckoned that five would be about the right answer, until he was reminded that calling a tail a leg did not make it one. Mr. Sabin calls the electrolytic theory untrue, and summarily disposes of it to his own satisfaction.

The facts brought out in numerous tests by a number of independent workers is constantly furnishing corroborative evidence of the truth of the electrolytic theory and of the value of this theory as applied to the selection of inhibitive paints for the protection of steel. It does not matter that this cumulative evidence should be ignored or lightly brushed aside by Mr. Sabin, as far as his own opinions are concerned. But it would be most unfortunate if any considerable number of engineers, responsible for the protection of steel, should allow themselves to be prejudiced against the results of scientific researches which promise to develop information of the highest value in respect to the problem of protection.

Yours truly,
Henry A. Gardner, Asst. Director,
The Institute of Industrial Research, Washington, D. C.,
May 13, 1911.

[To the foregoing criticism Mr. Sabin has made the following reply.—Ed.]

Sir: Calling a man a reactionary is not a serious offense, and in this instance is probably complimentary; but saying that I "call the electrolytic theory untrue" is not in agreement with the fact. I merely stated concisely the two theories, and pointed out the difficulty of disproving either; also, in the sentence immediately following the one quoted, that there is nothing in the so-called electrolytic theory inconsistent with the well-known fact that carbonic acid stimulates corrosion, and that the engineers' problem is how to keep moisture, air and acid gases from the surface of the metal. The "interests" with which I am affiliated could not be prejudiced by the acceptance of this theory, and are business rivals of the carbon paint people; nevertheless I will not conceal my disbelief in the statement that carbon is a poison to metal, as held by the too "numerous publications of a band of trained investigators," who, so far as I know, never made any paint and never painted a bridge.

A. H. Sabin.
Research Laboratories, National Lead Co., 129 York St., Brooklyn, N. Y. C., May 19, 1911.

Sir: I have read, in your issue of May 11, an article by Prof. Sabin, regarding the corrosion of iron and steel, and stating his erroneous viewpoint regarding the electrolytic theory.

As a practical experienced painter who has followed recent developments in the science of rust prevention, I cannot refrain from giving my own views on this very important subject. I visited the office of Public Roads of the Agriculture Department, during that period, three or four years ago, when Dr. Cushman was first making those experiments on the corrosion of iron and the inhibitive power of certain pigments, which later on suggested the practical paint tests on steel panels, which were erected at Atlantic City, N. J., by the Paint Manufacturers' Association, under the supervision of the American Society for Testing Materials. I have watched these field tests with great interest, and can vouch for their value. Any practical painter who will take the trouble to inspect the tests, will readily acknowledge the superior wearing value of the inhibitive type of pigments. These have given excellent service over nearly three years, and are in good condition to-day. The report of Committee U of the American Society for Testing Materials, which was published in their Proceedings for 1910, confirms my own findings regarding these tests.

I have painted the iron construction on some of the largest government buildings in Washington, as well as on several other important jobs and I have come to the conclusion that there is nothing better to use for the painting of iron and steel than a good inhibitive coating, designed along these lines which are suggested by the Atlantic City tests.

Very respectfully,
Chas. Macnichol.
428 Tenth St., N. W., Washington, D. C., May 17, 1911.

The Corrosion of Wrought-Iron and Steel, and the Improvement of Steel.

Sir: May I add a word to what you say in your issue of April 20 on this subject, for the purpose of defining the matter a little more accurately?

I do not think that I have ever said sanything which could be taken to mean that it was established that there was no difference in corrosion between wrought-iron and steel. In the remarks to which you probably refer my position was that, in view of the modifications in the manufacture of steel tubes introduced in late years, it was well to suspend judgment on the question as to whether these modern steel tubes would or would not rust faster than wrought-iron tubes. The evidence then before me did not justify an inference that they would. Nor have we evidence that the other modern steels, designed especially for resisting corrosion, such as the dead-soft basic open-hearth steels, corrode faster than wrought-iron.

You have mistaken my position in inferring that I regard it a waste of time to find reasons for the difference of behavior of the two materials. Such reasons I have repeatedly explained and insisted on. Their influence may be very important. One part of the difference is that steel lacks the great quantity of cinder which wrought-iron contains. This cinder may on one hand benefit wrought-iron by acting mechanically as a barrier to impede the progress of corrosion. On the other hand, by setting up a difference of potential it tends to increase corrosion.

Beyond this, much wrought-iron has an advantage over most steel in having less manganese and carbon, to set up differences of potential; but on the other hand most wrought-iron has very much more phosphorus than the purer steels specially designed to resist corrosion, and in this respect is more subject to differences of potential and consequent auto-electrolysis. What the resultant of these several influences of opposite sign may be in any given case it is impossible to foretell. It must vary not only with the environment but with the composition and structure of the two metals. The difference in constitution between steel and wrought-iron is very marked, and might easily lead to a material difference in the rate of corrosion. It is a matter purely for observation whether under given specific conditions of practice wrought-iron or properly made steel corrodes the faster.

There is steel and steel. The mere fact that certain steel corrodes faster than the wrought-iron with which it is compared does not in itself show that steel made purposely and intelligently with a view to lessening its corrosion corrodes faster than wrought-iron. Of course it may be proved that even the least corrodible steel corrodes under many or even under all conditions more than the least corrodible wrought-iron, but the serious efforts of steelmakers to lessen the corrodibility of their product entitles them to a hearing on this point, and those whose interest is purely scientific may weil suspend judgment. I for one should welcome any evidence in either direction as tending to answer an important question. In the same way I welcome the evidence which you give as tending to confirm the general belief that steel as formerly currently made for the purpose you consider was in a general way more corrodible than the wrought-iron with which it competed. But the conclusion that, because past ill-made steels have misbehaved, the present attempts to increase the rust-proofness of steel must fail, seems to me unjustified.

Henry M. Howe.

Columbia University, May 11, 1911.

[We agree heartily with Prof. Howe in his general position stated above. The view we meant to combat is one which has been repeatedly expressed in papers and discussions, namely, that the claims of experience proving steel to rust faster than wrought-iron are not supported by evidence, whether old or new. It was our impression that Prof. Howe had upheld this view, and had stated that he was unable to find any recorded experience of reliable character showing wrought-iron to stand better than steel. Coming to present-day steels, of course, the question is on a new footing. We concede that steels have often been produced which showed a surprising degree of rust-resistance, though we do not know of convincing proof that this result is or has been produced regularly. There is reason to hope, however, that such knowledge and skill may be attained that steels of high resistance to rusting can be produced at will, and with certainty. Certainly we do not hold that steel simply cannot, by its very nature, be made slower rusting than the ordinary product, wherein we agree fully with the last sentence of the above letter.—Ed.]

Addressing Letters to a Corporation.

Sir—It is remarkable that there is so little information on the part of the great army of stenographers, clerks, bookkeepers, etc., as to the proper manner in which leters should be addressed to railway officials.

For example, many concerns doing business with the New York Central & Hudson River R. R. Co. will address an envelope, which contains important matter requiring prompt attention, as follows:

"N. Y. C. & H. R. R. R. CO.,
New York City,"

in evident ignorance of the fact that a letter so addressed may be delivered at any one of over one hundred different offices of the N. Y. C. & H. R. R. R. Co. in New York City.

There is every possible chance that a letter so addressed will fall into the hands of someone just as careless as the person who addressed the envelope, and that the communication will never reach its destination. If it does go where it belongs, special messenger service is frequently necessary.

All communications to any railway officials should be enclosed in envelopes addressed to that officer in his official capacity, for example:

"MR. J. M. JONES,
Vice-Pres., B. & T. V. R. R.,
Jonesville, Ky."

If the name of the railway official is not known, then simply address the envelope to that officer, as follows:

"Vice-Pres., B. & T. V. R. R.,
Jonesville, Ky."

and it will be delivered to the proper person.

H. C. I.

Kansas City, Mo., May 15, 1911.

[The question raised by our correspondent suggests others of a still broader scope. Not only railway companies but many large industrial organizations have great difficulty in sorting and delivering mail, and particularly in finding the destination of letters which refer to previous correspondence and which are addressed merely to the company. The confusion in the public mind between holding companies and subsidiary concerns in large organizations often causes letters to pursue a very roundabout course to their destination.

It was formerly the custom to request the address of all letters to the company and not individuals connected with it. With present day complex organizations the better plan appears to be to request the address of mail, so far as possible, to departments, where the name of the person it is desired to reach is unknown.—Ed.]

A Remarkable Recovery of Old Survey Marks.

Sir: The following story of how the axe marks on a corner tree were found after the tree was entirely gone may be of interest. The story is vouched for by Mr. George D. Blair, President of the Elliott-Blair Steel Company, New Castle, Pa.

The engineer who found these phantom marks was Henry Wilson, years ago County Surveyor of Huntingdon County, Pa., one of the finest of that race of land surveyors who marked out our Pennsylvania homesteads. In 1876 Mr. Wilson was employed in running the lines of an old furnace property and incidentally in a hunt for land marks scattered over some 20,000 acres of mountain land in Blair and Huntingdon Counties.

Skilled in the wood craft of his profession, sharp of eye, and honest in his own work and with that of others, he was a pleasant and inspiring companion. Some of the boys of the party smiled the first day, because the old gentleman, stiff and sore, started slowly; but as he warmed to the hunt, there was not so much "snickering in the back seats," and by 6 p. m. the boys had a wholesome respect for the physical vigor of the old man.

We also, like the boys, are inclined sometimes to smile at the work of these pioneer surveyors, but measured by efficiency, the economical use of means to an end, their work will stand comparison with the best.

The call for one important corner was for a "jack pine" tree. The measures, after certain corrections, located the spot within 50 ft. or so in a bit of woodland. No pine of any kind was there. The old gentleman, who had been "ranging" like a hound off the trail, suddenly stopped and called our attention to a long narrow strip of ground where there was enough difference in the character of the growth on the forest floor to convince us that once a fallen tree had rotted away there. Starting 3 or 4 ft. from what had probably been the butt of the fallen tree, he began to poke around in the thick mold, and after a bit drew out what looked like a pine knot, but which turned out to be a piece of pine covered with resin. In this wood was a distinct axe mark. Hunting on he found at about 18 ins. and 36 ins., respectively, farther along this streak, two pieces, and no more, exactly similar "pine knots," each with the same distinct axe mark. He had truly found the axe marks in a tree after the tree itself was entirely gone.

The "fat" resinous "jack pine" had healed its ax wounds with resin and left an almost indestructible monument for the skill of the old gentleman to uncover.

G. B. Zahniser.

Civil Engr., Clendenin Block, New Castle, Pa., May 6, 1911.

A Primitive Sugar-Mill in Panama.

Sir—The American engineer in Panama who wanders away from the line of the canal into the jungle finds many things of interest there, although few are works of engineering. The dense tropical vegetation, with its infinite variety—the birds, the insects and the reptiles—combine to make him realize that he is in a strange land; but he feels most like a foreigner when he goes into a native village, made up of huts of bamboo poles with palm-thatched roofs, and sees the home life of the people and their little half-cultivated gardens where they raise yams, bananas, corn and cane.

One does not expect to find engineers developing in such surroundings, yet occasionally there is seen some device which appears to be the result of intelligent thought and clever execution. The execution is especially interesting when one remembers that the only tool the Panamanian uses is the machete, and that this murderous-looking knife serves as ax, hoe, pick and scythe, and is used for all domestic purposes except cutting the hair of the numerous little naked children.

The occasional horse-driven sugar mill which one finds does not impress the visitor with any respect for the mechanical ability of the natives, for it was undoubtedly made in the States and freighted down to Colon, to be packed into the jungle on the backs of some of the ridiculously little horses one sees everywhere in Panama; but the writer found, on the upper slopes of Cerro Gordo, less than two miles from the canal headquarters in Culebra, a sugar press of native design and construction which, though not economical in operation, nevertheless does the work its designer intended.

It consisted of a tree trunk, notched half way through, a hole bored a few inches above the flat side of the notch, and a stick fitted loosely into the hole to give a good leverage. A piece of sheet metal from an old kerosene tin formed a trough to lead the juice from the squeezed cane away from the tree, so that it dropped into a receptacle.

Had its builder been born in a less enervating climate he would probably now be designing intricate machinery instead of squatting idly in the shade, waiting for a papaya to ripen and fall within reach. S. C. E.

Culebra, Canal Zone, May 4, 1911.

A SMALL BUT COMPLICATED SEWAGE PURIFICATION plant at Darfield, England, was opened in March, 1911, according to a brief description of the works in the London "Contract Journal" for April 5, 1911. The district involved has a population of 5,500 persons and a dry-weather sewage flow of a little under 100,000 U. S. gals. per day. The disposal works provide for treating 120,000 U. S. gals. per day. On reaching the works the sewage passes through detritus tanks, provided in duplicate, and through screens, and then goes to an open storage tank of 72,000 U. S. gals. capacity, sufficient to hold the normal night flow. Two centrifugal pumps, of 30,000 U. S. gals. capacity per hr., are provided to lift the sewage to a receiving tank, with a capacity of 62,500 U. S. gals. Before the sewage reaches this tank, it is dosed in the mixing chamber with alumino-ferric at the rate of about five grains per U. S. gal. The sewage flows from the receiving tank into duplicate precipitation tanks, divided by cross walls into compartments. Each compartment has a dished bottom, from which sludge is drawn by gravity. The clarified tank effluent goes to an automatic dosing chamber, from which it is discharged on to four primary percolating filters, each 5 ft. in depth, distribution being effected by revolving sprinklers. The primary sprinkling filter effluent goes to a combined dosing chamber and humus tank, from which it is discharged on to two secondary percolating filters, each 5½ ft. in depth. These filters have the same cubic capacity as the primary filters. The secondary sprinkling filter effluent goes to duplicate humus tanks, from which it is finally discharged into the River Dearne. The sludge from the receiving and the precipitation tanks is discharged by gravity on the land, where it is either buried in trenches or else dried in lagoons and subsequently removed by carts. The sewage is said to be very strong, "equal probably to Normanton sewage, which was one of the strongest tested by the Royal Commission [on Sewage Disposal], and requires very careful treatment." The works were started up about four months prior to the official date of opening mentioned above. No night pumping is done, except in times of storm. The engineers for the disposal works were D. Balfour & Son, of Newcastle-on-Tyne and London.

Two 4,000-HP. Geared Turbines for U. S. Collier "Neptune."*

The two 4,000-HP. marine turbines, with reduction gears for U. S. Collier "Neptune" have recently been finished by the Westinghouse Machine Co., and one is now being installed in the hull. The second unit will be installed in a few days to enable the official trials of the "Neptune" to be made in June. These trials will be watched with interest by naval engineers and architects, since it is claimed that the weight of this propelling machinery will be less than half that of direct-connected turbine units or of reciprocating units, and that, at cruising speeds, 20 to 30% less steam will be used than by these other vessels.

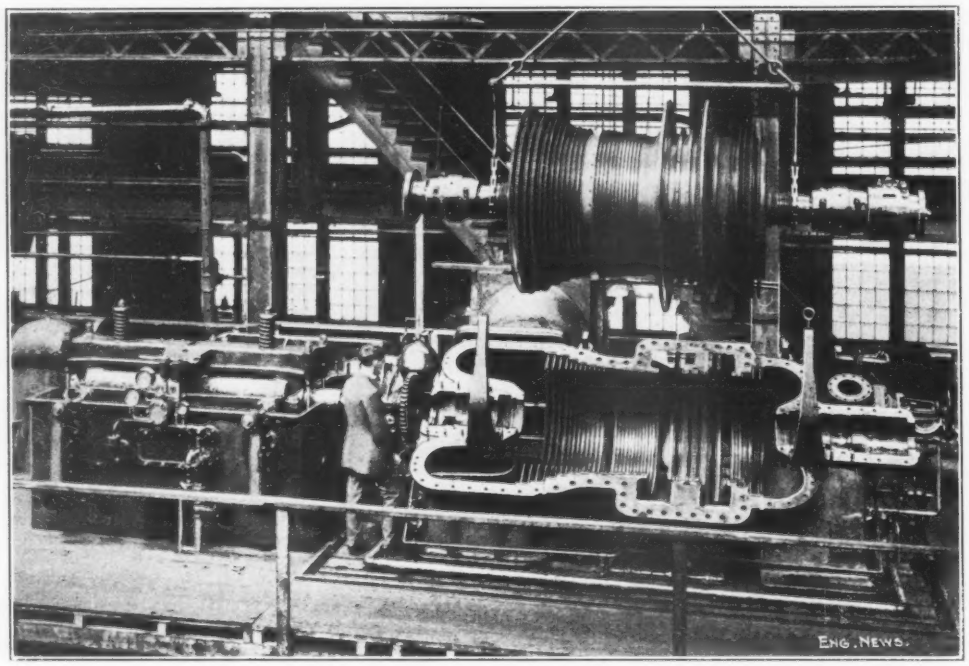

FIG. 1. WESTINGHOUSE 4,000-HP., MARINE STEAM TURBINE AND REDUCTION GEAR FOR U. S. COLLIER "NEPTUNE."

(The gear has been removed from the gear case and the turbine rotor is being lifted out of the cylinder.)

The arrangement, as proposed, has already been described in Engineering News (April 7, 1910, and Jan. 12, 1911). The units as built are shown in the accompanying figures.

All steam and exhaust connections are made to the lower half of the turbine and the general construction is such that the steam may be turned directly into the apparatus when cold and full speed attained in less than one minute. The form and dimension of turbines which have heretofore been used for naval service have been such that the turbines required pre-heating before starting, such pre-heating taking from three to ten hours, according to the size of the machinery.

The upper half of the turbine is arranged, so that it can be quickly thrown back upon its hinges in order that all of the blading of the turbine may be quickly inspected. To illustrate the value of this feature to Admirals Bethedar and Garcia of the Argentine Navy and Rear-Admiral Cone, Engineer-in-Chief of the U. S. Navy, who have just visited Pittsburg for a critical inspection of the apparatus, the top cover of the turbine was loosened, removed from its place, the rotor containing the blades given a complete revolution by hand, and the cover restored to its place and the turbine again started, all in 50 minutes. In contrast several days are reported to be required to open up and similarly inspect the turbines for one of the screws of a modern battleship.

It is reported that the means of "floating" the pinion frame has been changed to provide an elastic motion and a separation of the mechanical connection between the frame of the pinion and the main casing. This, it is claimed, reduces vibration from the meshing of the gears and also provides a hydraulic dynamometer which will permit of reading the exact propeller shaft horsepower from a gage.

Each turbine has an ahead, an astern, and a cruising section within one casing. As previously noted the control mechanism is so arranged that each engine may be run in either direction at any speed up to the maximum, either by mechanism operated in the engine-room or by a duplicate operated from the bridge of the ship. The man on the bridge can reverse either or both turbines from full speed ahead to full speed astern in less than 15 seconds, or in much less time than it now takes to communicate signals from the bridge to the engine-room with other types of control. In the event of the steering apparatus being disabled, the ship can be steered and kept to its course by the manipulation of the speed of the turbines. The overspeeding of the turbine engines from any cause whatever, and especially in a heavy sea, is automatically prevented by the governor control.

The Navy Department has already applied a number of Parsons and Curtis turbines for the propulsion of war vessels, and after prolonged tests, the General Board reached a conclusion, which it recently promulgated publicly that no further battleships would be fitted with turbine machinery of the kind so far experimented with. The controlling reason for this decision is the large amount of steam and coal required to propel these ships at cruising speeds with turbines, as compared with reciprocating engines. It is believed, by the builders of the "Neptune" turbines, that the trials of the "Neptune" will change the entire situation with reference to the application of power to naval vessels, and demonstrate the practicability of reduction gears for the largest units.

*From information furnished by Mr. H. E. Longwell, Consulting Engineer, Westinghouse Machine Co., East Pittsburg, Pa.

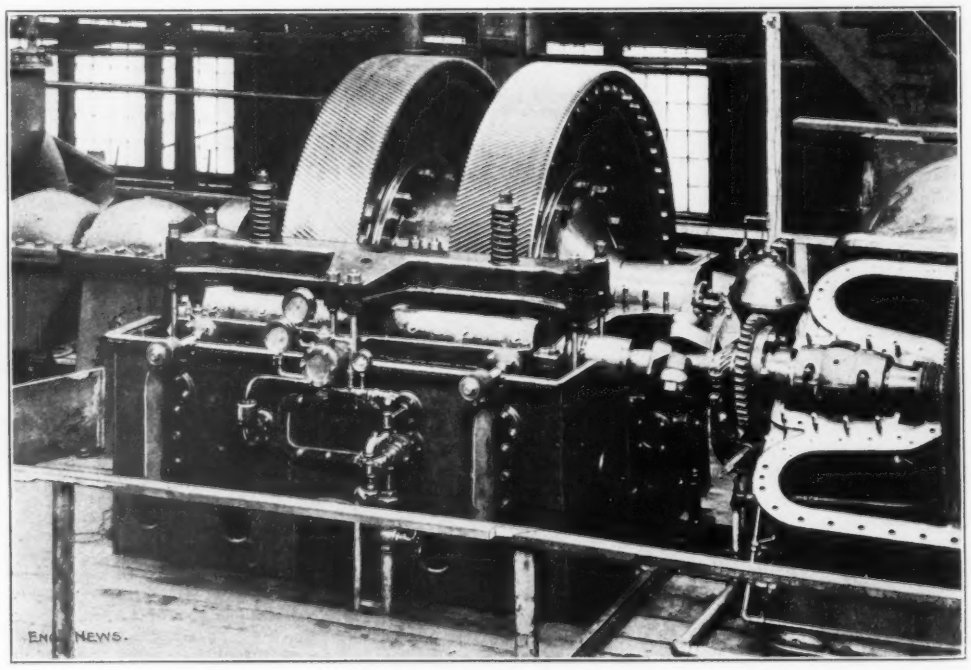

FIG. 2. REDUCTION GEAR OF MARINE STEAM TURBINE UNIT FOR U. S. COLLIER "NEPTUNE."

(Cover of case removed; gages of dynamometers shown on the front of the casing.)

A Year's Experience with Geared Marine Steam Turbines.

A paper was read by Messrs. C. A. Parsons and R. J. Walker before a recent meeting of the Institution of Naval Architects (of Great Britain) describing the year's experience with geared turbines on the "Vespasian" (described in Eng. News, April 14, 1910). From an abstract of the paper and discussion, in the London "Times" Engineering Supplement, April 12, it appears that the "Vespasian" was placed in regular service, on June 9, 1910, carrying coal from the Tyne to the Continent and returning with water ballast. In this time, 26 trips to Rotterdam and six to Antwerp were made, aggregating 20,000 miles. The machinery was frequently inspected and tested and practically no slackness or wear was found.

The report continues:

During the winter months the vessel encountered some exceptionally severe weather, especially in light condition, but the turbines and gearing worked throughout with entire satisfaction, and did not give the least trouble. A very noticeable feature had been the remarkable freedom from racing of the engines under conditions when the propeller was entirely out of the water, confirming the observations made on the earlier trials when the engines, under the worst conditions, did not tend to accelerate in revolutions more than 16%. The engineer of the vessel reported that, without the aid of a sensitive tachometer, it was very difficult to observe any acceleration in the speed of the engines.

With a view to experimenting with different qualities of steel, additional pinions were made, one of chrome-nickel steel with a tensile strength of 55 tons, elasti-

limit of 38 tons, and an elongation of 20% in a length of 2 ins.; and two of special carbon steel of 40 to 45 tons tensile strength, elastic limit 22½ tons, and an elongation of 20 to 25%. The original pinions were of mild chrome-nickel steel with a tensile strength of 37 to 38 tons, and an elastic limit of 32 tons.

The chrome-nickel steel pinion of 55 tons tensile strength was tried in August last, but was removed after two voyages, as on examination it was found to be fractured at the corners of some of the teeth. This appeared to be due to the teeth having been irregularly machined and bearing over one-third of their length only; the material also appeared to be of too brittle a nature.

At the end of last year a new propeller was fitted to the vessel with a finer pitch ratio than the original one. Its actual dimensions were: diameter, 14 ft.; pitch, 14-14 ft., and expanded blade area, 72 sq. ft., as compared with the original propeller of 14 ft. diameter, 16-35 ft. pitch and 70 sq. ft. expanded area. Trials showed that at 9-3 knots, which was about the average service speed of the vessel, the water consumption per hour had been further reduced with the new propeller by about 7%, 4% being attributable to the increased efficiency of the turbines running at the higher revolutions, and the remaining 3% to the slightly increased efficiency of the propeller.

In regard to the question of economy generally, the authors did not profess that the results obtained with the "Vespasian" were the highest obtainable with geared turbines. In a new vessel, and with new boilers, say, of about 180 lbs. pressure, a consumption of about 12½ to 13 lbs. per shaft HP. of the main engines, as compared with 16 lbs. at the service speed of the "Vespasian," could confidently be expected in an installation of, say, 1,000 HP., which would be equivalent to 11½ or 12 lbs. per I.HP. of reciprocating engines, assuming a ratio of shaft to indicated horse-power of 91 to 92%.

A 750-HP. Geared Steam Turbine in an English Steel Mill.

At the time of the "Vespasian" undertaking, a new rolling mill was being installed in the Calderbank steel works of Messrs. James Dunlap & Co. It was proposed to use the exhaust steam from existing mill-engines for driving the new mill, and it was also proposed to use an existing flywheel for equalizing the load and wiping out the sharp short peaks. An electrical generator-motor speed-reducing set was first proposed, in connection with a high-speed steam-turbine drive, but this was abandoned for a double reduction gear of the Parsons type. This is described in London "Engineering," April 7, from which the following information has been abstracted:

The mill is a three-high type with rolls 28 ins. in diameter by 84 ins. long. The rolls on the mill tables and the screws applying the pinch on the main rolls are electrically operated. The lifting tables are hydraulic and the whole control is given to two men in glazed cabins near the mill.

The turbine is a Parsons mixed-pressure type of 750 HP., running at 2,600 r. p. m., on exhaust steam at 16 lbs., absolute, or on live steam at 60 lbs gage. There are two inlets for these supplies—one at the high-pressure end and the other near the center of the cylinder. Each inlet has a steam chest and governed valves arranged to give preference to an exhaust supply if any is available. When this exhaust is insufficient, or ceases, the balance of energy is automatically supplied from the high-pressure steam line.

The mill runs at 70 r. p. m. and the turbine speed of 2,000 r. p. m. is reduced in two steps, the intermediate shaft running at 375 r. p. m. The high-speed pinion is of chrome-nickel steel forged solid with its shaft. The pitch-line diameter is 7.143 ins. and there are 25 teeth, 3½ ins. diametral pitch. The meshing gear is 37.429 ins. in diameter with 131 teeth and a 24-in. width of face. Both sets of reduction gears have double-helical teeth, cut at an angle of 23° with the shaft axis, in a special hobbing machine. The second-reduction pinion is of forged mild steel and has 23 teeth of 2-in. circular pitch. The pitch-circle is 14.912 ins. in diameter and that of the meshing gear is 80.848 ins. with 127 teeth. The width of face of this low-speed gear is only 6 ins. Both pairs of gears run in cast-iron cases. The bearings are lubricated by oil, at a pressure of 8 to 10 lbs., from a pump driven by an extension of the governor shaft. The gears are lubricated by a separate oil pump chain driven from the intermediate shaft. Oil is drawn from settling chambers in the bottom of the gear cases and sprayed onto the teeth.

The fly-wheel, with its shaft, weighs nearly 100 tons, and is carried on two 22-in. diameter adjustable gun-metal bearings, one of which forms part of the low-speed gear-box. The low-speed gear-wheel is keyed directly on to the end of the fly-wheel shaft, and is overhung from its bearing. The sides of the rim are turned true so as to form the track for a pair of hydraulic brakes, which enable the whole plant to be brought to rest in 25 seconds in case of emergency. The external diameter of the wheel is 23 ft. The stored energy in the fly-wheel is about 20 times that of the turbine and gears, so that the latter can get only a small fraction of the shock which comes on the mill-rolls.

The fly-wheel shaft is connected to the main pinion of the mill by a pair of wobbling couplings. One of these is of cast steel of ample strength, while the other is of cast iron of such a section as to allow of its breaking in the event of any undue strain on the mill. (Four of these couplings were broken in one afternoon.)

Up to the present time (since Sept. 15, 1910) the plant has been working mostly on live steam, for the simple reason that the turbine-driven mill has been able to roll practically all the slabs that the heating arrangements can deal with, and the only exhaust steam is that which is discharged by the cogging-mill, which is very intermittent. There has consequently been very little exhaust steam available, but when trade is sufficiently brisk to warrant the use of further heating furnaces, both mills will be kept going, and will provide sufficient exhaust steam to enable the turbine to run with only an occasional whiff of live steam.

The general experience which has been obtained with the working of this plant is sufficient to show that the experiment has proved a most gratifying success. The mill has been working regularly ever since the heavy bearings have got settled down into good working order, and no trouble of any sort has occurred. The gears are better to-day than they were when first set to work, and no wear is observable other than a slight polishing of the working faces of the teeth.

The Third National Conference on City Planning.

The Third National Conference on City Planning was held at Philadelphia on May 15 to 17. There was a creditably large attendance and an excellent program of papers and discussions. Interest and value were added to the conference by an Exhibition of City Planning, organized and conducted by the City of Philadelphia. The exhibition consisted principally of drawings and photographs illustrating the projects and achievements of more than a hundred cities in the United States, Canada, South America, France, Germany and England.

Three men notable for their town planning and "Garden City" work in England were present at the conference and added materially to its success. The attendance from American cities included a considerable number of prominent engineers and landscape architects.

The papers and discussions dealt almost wholly with practical fundamental phases of city planning. Not a single paper was devoted to the esthetics of the subject, and the few references which were made to the artistic side of city planning were minor and quite incidental.

We mention this because the idea has got abroad that the new city planning movement centers around the idea of "the city beautiful," whereas it is chiefly concerned with just what the name indicates, the basic plans of the city, including streets, parks and the relation of public and private buildings to each. Associated with the physical aspects of the subject are various financial, sociological and governmental problems which also demand serious consideration.

The number of papers presented at the conference was limited so as to concentrate attention on important subjects and to afford opportunity for full discussion. Much of the discussion, however, was formal, to the extent that those who were to participate in it were selected in advance. Usually, time was available for informal discussion. The main topics chosen for each of the seven sessions were as follows: (1) Municipal Real Estate Policies; (2) Public Buildings in General and Their Location in Reference to Parks and Open Spaces; (3) Buildings in Relation to Street and Sites; (4) Taxes, Assessments and Condemnation; (5) Dock and Harbor Improvements; (6) Street Widths and Their Subdivisions, and (7) A Uniform City Planning Code.

The conference was entertained by the City of Philadelphia, various local organizations and a Woman's Committee. At 9 a. m. on the opening day a city planning automobile tour started from the City Hall in order to give those in attendance at the conference an idea of what Philadelphia proposes and has already achieved in the way of city planning. The conference closed with a banquet on the night of its third day. In addition, there were luncheons and various other entertainments.

The formal sessions of the conference were opened by an address of welcome by Mr. John E. Reyburn, Mayor of Philadelphia, who took part in the proceedings throughout. A response to this address was made by Mr. Frederick Law Olmsted, of Brookline, Mass., Chairman of the Executive Committee of the conference and Professor of Landscape Architecture at Harvard University.

German Municipal Real Estate Policies.

Some of the work done by German cities in city planning was outlined by Mr. Frederick C. Howe, of Washington, D. C. In Germany, the city is supreme. In the United States private interests govern. A German city enjoys almost supreme home rule. The American city is subject to legislative control. Every German city now has a plan formulated by landscape architects and by engineers and other specialists working together. Many German cities are large owners of land from which heavy revenues are derived. The cities have adopted the policy of "excess condemnation," or taking more land than is required for city improvements, selling the surplus at sufficient profit to pay for all or a part of the cost of improvement. The taxation of the unearned increment is also common. In some cases this tax amounts to from 33 to 40% of the increase in its value.

Mr. Thomas Adams, City Planning Expert of the Local Government Board of England, opened the discussion on Mr. Howe's paper. He first gave a greeting from Mr. John Burns, President of the Local Government Board. After this, he outlined the general features of the recent British Town Planning Act (see editorial review, Eng. News, March 17, 1910).

Public Buildings, and Their Location in Parks and Other Public Open Spaces.

A paper on "Public Buildings" was presented by Mr. Ernest Flagg, of New York City. After showing how the advent of steel skeleton buildings in America had been really the introduction of a new type of construction rather than a new type of architecture, and remarking that the recent introduction of steel construction in France bids fair to be accompanied by complementary architectural development, Mr. Flagg made some remarks on the height and location of public buildings.

He asked whether we were likely in this country to use low structures for public buildings or out-Herod Herod by making our public buildings even taller than our business structures. He thought the latter was likely, and predicted that within 25 years American cities would be running up public buildings 2,000 ft. in height. He brought in here his suggestions, previously made public, looking to a limitation on the height of that portion of buildings occupying a space equal to the whole ground area, but with no limit to the height of the tower portion of the buildings.

As regards sites for public buildings, he suggested that we might in this country well follow the example of European cities in clearing slum areas for city replanning purposes and in utilizing a portion of them as sites of public buildings. When public buildings are located in an old business center, they add but little to the taxable value of the district and destroy old landmarks. By going a little to one side of business centers, land could be secured at low cost and the value of the whole district be materially increased by the erection of public buildings.

Mr. Frank Miles Day, of Philadelphia, read a paper on "The Location of Public Buildings in Parks and Other Public Open Spaces." He called attention to the large sums of money often expended in the acquisition of lands for public parks and squares and the continual pressure which is being brought upon public authorities to place public and semi-public buildings within these areas.

In essentially park areas, whose original justification was their sylvan landscape effect, buildings are generally an intrusion. There may be cases, however, where a portion of park land is naturally separated from the remainder or perhaps surrounded by buildings in such a way as to make it advisable to use these special areas as sites for public buildings.

Mr. Thomas Mawson, of the University of Liverpool, England, took exception to a statement by Mr. Day that architectural objects are out of harmony with rural landscapes. Mr. Mawson thought that instead architectural objects give a poetic and romantic touch to parks.

Mr. F. L. Olmsted remarked that a park now without a public building, which would be better if it had one, was faulty in its original design. Where architectural features mar parks and open spaces, this is usually due to haphazard location of the buildings or a vacillating policy. Sometimes to re-design a park is necessary on account of an original mistake in laying it out or because of changed conditions. The Museum of Natural History did not invade Central Park, New York, but instead a piece of land not suited to the general purposes of Central Park and partly separated from it was completely cut off and dedicated to a new purpose.

In planning new tracts or additions to cities, it is advisable to make reservations for future public use, final use to depend upon circumstances. Some of these areas may finally be occupied by public buildings.

A member from Baltimore remarked that boulevards in open spaces in that city would have saved a large part of the fire loss which took place at the time of the great conflagration there. He also said that using small open spaces for buildings was generally an example of trying to get something for nothing.

Buildings in Relation to Street and Site.

This subject was introduced by Mr. Lawrence Veiller, of the National Housing Association, New York City. As an illustration of the fact that city planning is not a full solution to the housing problem, he said that Washington is one of the best planned cities in the world and has some of the worst slums. City planning has three important relations to housing: (1) regulations of heights of buildings; (2) depths of lots, and (3) width of alleys.

Mr. Veiller presented his subject largely from the viewpoint of the housing of the so-called working classes, with particular relation to populations of foreign origin and but small earning capacity. All sentimentalities aside, and viewing only the known habits and financial limitations of these classes, the best means of housing them is to limit lot depths to 25 ft. and build rows of houses occupying the full depth of the lots. Such houses would be only two rooms deep, and thus every room would have light and air. Where great masses of people must be housed, back yards and play places have generally been a failure. Where land is reserved for front or rear yards it soon becomes bare ground and is littered with rubbish. It is, therefore, useless to provide more space than what is required for light and air. Even in relatively small towns there is a remarkably strong opposition to any limitations put upon the utilization of land for building purposes.

It should be clearly understood that the 25-ft. solidly-built-up lot is designed only for unskilled laborers with limited means and desires. The author suggested more liberal provision for other classes of laborers, such as lots of 50 ft. and 125 ft. in depth. He remarked that to get away from the uniform street and block plans would be a revolutionary step in city planning in America, but submitted the proposition as an eminently practical one worthy of consideration.

The alley was characterized by Mr. Veiller as both a blessing and a curse. It has value for light and air purposes, but is generally an evil through becoming a dumping ground for all sorts of cast-off material, besides harboring serious nuisances. In a number of cities alleys are not a distinct evil. Where they exist they should be paved, lighted and cleaned by the city, receiving the same treatment and care as streets.

As to the regulation of heights of buildings, the author remarked that hotels and some office buildings must be high in practically all cities of any size, but that outside of New York City there is sufficient room to render tall buildings for general use unnecessary. The first thing to be done is to get streets right as to widths, and then to make the buildings conform to the widths of the streets. Outside of New York and Boston there is no reason why building heights should not be limited to the widths of the streets. As a rule, a height of six stories should not be exceeded except in selected areas.

Mr. Raymond Unwin, of London, England, author of "Town Planning in Practice," said that he believed that city planning could be made to do more for housing than Mr. Veiller thinks. In densely populated England a space of 15 ft. is required at the rear of each house line, or 30 ft. in all between rear house lines, and the height of the house is limited to three stories. Mr. Unwin also took issue with Mr. Veiller's ideas as to the advisability of providing garden spaces for laborers. He urged that sanitary abuses in alleys should be prevented instead of permitted. He thought that the block dwelling so common in the United States, and which is sometimes displacing the single dwelling in England, is very harmful. Some of the population should be carried into the suburbs, as in the garden cities and garden suburbs. The British Town Planning Act, he remarked, provides for controlling all these matters.

Mr. Unwin also stated that streets are the most expensive and disagreeable form of open spaces that can be provided for the people. Building fewer houses to the acre but slightly increases the rental value of the house and grounds combined. Estimates show that three times the lot area can be provided for only 25% additional rental charge.

Mr. Thomas Adams, of London, said that the people of England are not docile, but that those of this country are. The English people refuse to be shut off from nature. He suggested that Mr. Veiller read the British Town Planning Act and learn that planning and housing are intimately related. The growth of cities must be directed into the suburbs. The alternative is not between ownership and tenantry. He had found by inquiry that land outside of cities is as cheap in the United States as in England.

In closing the discussion, Mr. Veiller mentioned some of the obstacles he had encountered during his fifteen years' work in attempting to bring about housing reform in American cities and to secure needed housing legislation in American States. So far as the population to be housed is concerned, we have to deal here with people from every country on the globe, which is very different from dealing with the homogeneous population of English cities. As an illustration of the difficulties encountered in securing legislation which will interfere with the personal liberties of the American citizen, Mr. Veiller said that for some weeks an attempt, thus far unsuccessful, has been under way to get an act through the Pennsylvania Legislature requiring that there should be one water faucet in every Philadelphia tenement; also, that while the Health Department of Philadelphia has the right to enter tenements for sanitary inspection it has no right to enter private houses for that purpose.

Taxes, Assessments and Condemnation.

The session devoted to this subject was presided over by Mr. Lawson Purdy, President of the Department of Taxes and Assessments, New York City. Mr. Purdy made some introductory remarks under the general title "How to Pay the City Planning Bill." He alluded to needed reforms in condemnation proceedings which would effect material economies. He also advocated the adoption of the excess condemnation principle and practice for American cities; an extension of assessments for betterments, and the taxation of land according to its value for improvement purposes.

Prof. Frank J. Goodnow, of Columbia University, remarked that in this country we rely too much upon private initiative in matters pertaining to city improvements. Thus, the law generally says that street improvements which are to be paid for by assessment for benefits shall not be instituted except on petition by the owners. The transportation of passengers and goods is in private hands, and, therefore, governed by the desire for profit instead of service. German cities control intra-mural transportation in the interest of the community, and in addition they have the co-operation of the State in the control of interstate railways to the same end. As a rule, American cities do nothing to discourage intensive development of city areas. They have never yet attempted to control the distribution of industry and population. Taxation must be considered from the point of view of its effect upon social conditions. Personal property, land and improvements should not be taxed at the same rate.

Water-Front and Harbor Improvements.

An evening was devoted to accounts of harbor and water-front improvements, accomplished or projected, at New York, Philadelphia, Baltimore, Los Angeles, Portland, Ore., St. Paul, and Toronto. This session was presided over by Mr. George E. Hooker, Secretary of the Chicago City Club, who remarked that the chief problem of water as well as rail transportation is that of terminals. Mr. Calvin W. Tomkins, Commissioner of Docks, New York City, gave some account of harbor and water-front development at New York, and outlined his plan for eliminating the New York Central railway tracks on 11th Ave. by means of an elevated railway with spur tracks giving other railway lines access from their car floats and still other spur tracks leading to factories on the land side of the railway. (See Eng. News, April 13, 1911, p. 447.) This plan would release the water front from car-float storage and make it available for steamships.

Mr. Joseph Hasskarl, M. Am. Soc. C. E., Director of the Department of Wharves, Docks and Ferries, Philadelphia, described improvements carried out or projected under his direction. The City of Philadelphia now owns 13 piers and proposes to provide large additional pier facilities. Congress has authorized the deep-water improvement of the Delaware River, but the city and State must dredge from the deep-water channel to the docks. The city has installed a dredging plant for this purpose.

Mr. Oscar F. Lackey, Harbor Engineer of Baltimore, said that the government has completed a channel 600 ft. wide with 35 ft. depth in Chesapeake Bay to the city harbor, and the city is carrying deep water to the docks. Since the great fire the city has spent $6,000,000 for piers and other water-terminal facilities. The Legislature has given authority for the expenditure of an additional $5,000,000 for water-terminal improvements. A water-front marginal street over 100 ft. wide is to be provided, probably with freight tracks.

In concluding the session, Mr. Hooker, the Chairman, remarked that the industrial and commercial interests of cities having water fronts should be linked by a connecting railway along those fronts, and that both the railways and the water fronts should be owned by the city.

Street Widths and Their Subdivision.

Mr. Nelson P. Lewis, M. Am. Soc. C. E., Chief Engineer of the Board of Estimate and Apportionment, New York City, and Chairman of the Conference Committee on Street Planning, introduced the above-named topic by remarking that readjustments of widths of old streets is sometimes possible and necessary, and may be effected by narrowing sidewalks and removing sidewalk obstructions, as has already been done on 5th Ave., New York City, and as is now under way or proposed for several other overcrowded thoroughfares.

The first paper presented at this session was by Mr. Charles Mulford Robinson, Civic Adviser, Rochester, N. Y. The paper was entitled "Narrowing of Minor Residence Streets as Affecting Tenant and Owners," and was summarized from

the chapters of a forthcoming book on "The Width and Arrangement of Streets," by Mr. Robinson, which is to be issued by the Book Department of Engineering News.

Minor residence streets, Mr. Robinson remarked, are more numerous than those of any other class. A rigid adherence to standard street widths, regardless of the character of the streets and their occupants, places unnecessary burdens on abutting property, on account of the heavy cost of improving the street surfaces—and the speaker might have added because of the unnecessary cost of the land itself. This discourages development. Narrower streets would divert traffic to streets better designed to carry it, and would thus diminish the up-keep and lengthen the life of the pavements of the minor streets. Where wide streets are needed for through traffic in residence districts, the cost and excessive needs of local traffic might be placed upon the town as a whole. Considerations of this character are particularly important where the number of houses to the acre is limited, as is now being done in England.

Mr. John Nolen, Landscape Architect, Cambridge, Mass., submitted a paper on "Standardized Street Widths." His basis for standardization is the required unit width for a line of vehicles in the roadway and a line of pedestrians on the sidewalk. He gave standard street widths adopted in Washington, D. C., and a number of German cities, and suggested a tentative standard for American cities in general to be adapted according to local circumstances. Mr. Nolen's paper is printed in full elsewhere in this issue.

In discussing the paper just outlined, Mr. B. A. Haldeman, Engineer in Charge of City Planning, Bureau of Surveys, Philadelphia, said that scientific study of each street problem is more important than any rules. It is always necessary to do more or less replanning. The most essential consideration is a wiser regard for the needs of the city, which should dominate private interests. The control of street planning should be vested in a strong administrative body.

Two important considerations are standard unit widths and the provision of an elastic street. Since there is no likelihood of legislation fixing the width of vehicles, the assumption of a unit vehicle width of 9 ft. would perhaps be wiser than 8 ft. An allowance of 2 ft. as a pedestrian unit might be assumed. A planting space of 4 ft. for narrow and 8 ft. for wide streets might also be assumed.

The elastic street would combine present economy with the possibility of a future increase in capacity. It might begin with a width of two vehicle units for a roadway, or 18 ft., with 6 ft. for each sidewalk, or a total width of 30 ft. The understanding, of course, is that streets under the elastic plan would be widened as traffic increased, but that meanwhile abutting property owners would have the reserve space virtually added to their front lawns. In conclusion, Mr. Haldeman said that skill, courage and power are more important than rules when dealing with street problems.

A paper on "The Street Surface" was next presented by Mr. Geo. W. Tillson, M. Am. Soc. C. E., now Consulting Engineer of the Borough of Brooklyn, New York City, but until recently Chief Engineer of the Bureau of Highways, Borough of Manhattan. The greater part of Mr. Tillson's paper consisted of a discussion of the various classes of city pavements. In his prefatory remarks, Mr. Tillson suggested a classification of streets into wholesale, retail and residential, with the idea of apportioning relative widths of roadway and sidewalk and choosing the pavement to suit various classes. Obviously, sidewalks for wholesale streets could be narrower and the roadways wider, relatively speaking, than those of retail streets. A roadway 42 ft. wide might be allowed with two 9-ft. sidewalks. The roadway width is based on an allowance of 13½ ft. on either side of the street for trucks being loaded, and 15 ft. for clear roadway for traffic, it being assumed that there would not be a continuous line of trucks under processes of loading on each side of the street.

In the course of his paper, Mr. Tillson remarked that no city in the United States knows what its street traffic is. Observations to partly make good this deficiency were conducted in the Borough of Manhattan last year.

"The Sub-Surface" of streets was considered in a paper by Mr. Geo. S. Webster, M. Am. Soc. C. E., Chief Engineer, Bureau of Surveys, Philadelphia. Since 1902, no vaults have been allowed beneath the Philadelphia streets nearer than 4 ft. to the surface, the prohibition being designed to give space for pipes and wires. No underground structures are allowed in Philadelphia for which a permit has not been secured from a board of city officials created for that purpose. Records of all permits and of construction are kept. The permit fees more than cover the cost of drafting, clerical and inspecting forces.

The Principles of a Uniform City Planning Code.

The final session was devoted to this topic, and was presided over by Mr. Walter L. Fisher, Secretary of the Interior Department, Washington, D. C. The subject was introduced by Mr. A. W. Crawford, Assistant City Solicitor of Philadelphia, who stated that the Hartford Commission on City Planning affords a precedent which may well be followed elsewhere, especially as it does not create a new administrative body to usurp the powers of already existing city officials.

Although the subject given on the program called for a planning code, Mr. Crawford stated that, in order to let each proposed grant of additional power to cities stand or fall (in the courts) by itself it had been thought best to submit a series of city planning acts, each dealing with separate subjects. Accordingly, one bill accompanying the paper (which was to a degree a report of the Committee on Legal and Administrative Methods) would permit cities to plot vacant areas and to reserve portions for public purposes without defining the use to which these reservations should be devoted. Another bill would authorize cities to place a limit on the heights of buildings in specified portions of the city. Still other acts contemplated would provide, among other things, for excess condemnation.

In discussing the topic for this session, Prof. Ernst Freund, of the University of Chicago Law School, recorded an objection to excess condemnation, either as a means of making profit for a city or of restricting the character of buildings adjacent to city improvements. He preferred an assessment of benefits for raising the cost of improvements, and he also preferred to condemn easements for restrictions on the use to be put to adjacent property. He did not believe in cities controlling the action of individuals as to the character of improvements made by them. He thought that a city planning commission should not be forced on a city, and that the powers of such commissions should be advisory; also, that city planning commissions should have the authority to employ experts from outside their own city.

Mr. Frank B. Williams, of Hartford, Conn., and New York City, questioned whether in the formation of city plan commissions the aim should be to make a commission of experts wholly or in part. He said that as a rule men available for service on city planning commissions could not find the time to give unpaid expert services to the city, while in the smaller cities it was not always possible to find experts in the various lines. Mr. Williams also was of the opinion that it may be possible to do much good city planning or improvement work through the exercise of the health and police powers, especially as regards the relief of congested districts.

Mr. F. L. Olmsted said that the matter of restrictions on the development of the land by its owners might be subject to the local-option principle, under which a certain percentage of the property owners in a given district might agree on restrictions which would then become applicable to the district as a whole.

Mr. Thomas Adams remarked that the British Town Planning Act had for the first time introduced into legislation the word "amenity" in addition to health as an object to be attained through municipal action. Commenting on the remarks of the previous speaker to the effect that the City of Frankfort, Germany, has never yet exercised the much-advertised powers given it a few years ago to take small irregular tracts of land from private owners and reapportion them so as to give better building sites and improve the city plan, Mr. Adams remarked that in England it had been found that compulsory powers are necessary in order to secure friendly agreements.

Business Session.

It was decided to continue the "Conference" form of organization instead of forming a permanent association, and to hold a Fourth Conference next year. The Executive Committee for 1910-11 was continued with power to add to its number. Mr. F. L. Olmsted, of Brookline, Mass., is Chairman of this committee, and Mr. Flavel Shurtleff, 19 Congress St., Boston, Mass., is Secretary.

A resolution was adopted authorizing the Executive Committee to ask the federal government and the various State governments to investigate the subject of city planning in the United States. Another resolution looks forward to the interchange of city planning and exhibit material with foreign conferences, the exhibits to be standardized so far as feasible with the idea of facilitating shipment and hanging.

THE USE OF THE COMMON DRINKING CUP in all public places in New Jersey is prohibited by legislation recently enacted. The State Board of Health is given "full authority to establish such reasonable rules and regulations" as it may deem necessary to make the prohibition effective. Violations of such rules and regulations will be held as misdemeanors, and violators will be liable to a fine not exceeding $25 for each offense.

DOUBLE-TRACKING AND GRADE REDUCTION ON the Pennsylvania Lines (Indianapolis Division).*—The improvements which are being made by the Pennsylvania Lines to provide additional facilities for handling traffic on the Indianapolis Division include double-tracking, grade and curve reduction, and the elimination of grade crossings. This division, extending from Columbus, Ohio, to Indianapolis (188 miles) carries the heavy through freight and passenger business between eastern points and Indianapolis and St. Louis.

Prior to the inauguration of the work now in progress, the line from Richmond, Ind., to Indianapolis (68 miles) was single track, with the exception of 6½ miles of double track in terminal yards. The double tracking authorized aggregates 25.9 miles, and is in two sections: 17.6 miles from Richmond to Dublin, and 8.3 miles from Dunreith to Knightstown. In connection with this work, it was decided to reduce the maximum grade from 1.1% to 0.7%. This necessitates changing the grade on 21.3 miles of line, but when completed it will enable the present locomotives to operate much heavier trains over this division, thereby increasing the efficiency of operation.

A change of line of about a mile is being made east of Knightstown. This will replace a 3° 50′ reverse curve and a 1° 32′ curve by a single 1° curve, saving some 121° of curvature and 880 ft. in distance. At other points where the change in grade is considerable, an entirely new double track roadbed is being constructed, and when this is completed the old line will be abandoned. Some idea of the magnitude of the work is given by the fact that no less than 25 street and highway crossings and two railway grade crossings are to be eliminated. This alone will entail the building of four overhead and 16 undergrade crossings, and the vacation of five highways formerly crossing the railway at grade. The double track road is to be elevated through Cambridge City, Raysville and Knightstown, and depressed through Dublin.

All masonry in this work is of plain or reinforced concrete. There have been built 19 concrete arch bridges, 13 steel trough floor bridges, and three plate-girder bridges. The three largest bridges are over streams at Centreville, Cambridge City and Knightstown. Each of these bridges has three 60-ft. arch spans and contains about 5,000 cu. yds. of concrete.

In making these improvements about 1,850,000 cu. yds. of earth have been handled and 71,000 cu. yds. of concrete masonry laid. For eight miles west of Richmond, the new tracks are practically completed and in operation. It is expected that the entire improvement to the Indianapolis Division, costing some $2,750,000 (over $106,000 per mile) will be completed during 1911.

*From information furnished by the Pennsylvania Railroad.

Measuring the Flow of Water in Large Pipe Lines.*

By R. M. HOSEA.†

About three years ago it became necessary to accurately measure the quantity of water flowing in three large pipe lines supplying the Minnequa Works of the Colorado Fuel & Iron Co., at Pueblo, Colo. Two of these pipe lines conduct the water from certain receiving reservoirs about 150 ft. higher than the works, and five miles therefrom, and form part of the gravity system of supply to which reference was made in the writer's paper on "A Colorado Mountain Reservoir" presented to this Society April 3, 1907.‡ One pipe is of 48 ins., the other of 28 ins. inside diameter, both of the wood stave, banded type. A third 28-in. pipe line (also wood stave) leads from Lake Minnequa about a mile distant and 35 ft. above the works. All these lines are connected to a standpipe and to the general distributing system of the plant, and can be used singly or in combination as desired. There is considerable fluctuation in pressure and

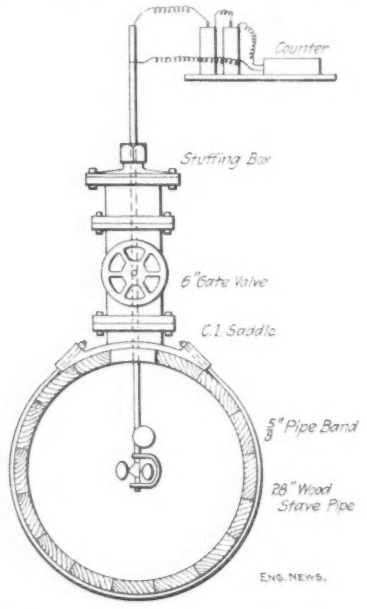

Fig. 1. Meter Inserted in Wood Stave Pipe.

in the amount of use, governed to a large extent by the operations of a repumping station and six blast furnaces.

Upon first taking up the problem there appeared to be only two recognized methods of measuring the flow of water in large pipe lines: (1) By means of the Venturi tube and attachments; (2) by the use of the Pitot tube or pitometer apparatus.

A pitometer apparatus was available, but it was decided that in expert hands only would results be satisfactory. It was found also that the cost of installation and operation of Venturi meters on the three pipe lines was greater than the results desired would justify. A thorough investigation of all known and accessible methods failed to disclose any cheap and simple "fool proof" apparatus for the purpose.

The insertion of a special form of current meter through an opening into the pipe in a similar manner to the pitometer and registering its revolutions by an electric contact point was thought to be entirely feasible.

The construction of a special meter was entrusted to a well-known maker of current meters and he produced a device which, after some changes and modifications, was put into use. It consists of the usual meter cups carried on a vertical spindle with steel pivot below and a guide bearing above. The spindle and upper bearing are within a closed cup-shaped chamber. By means of a worm-gear-drive, a dial plate carrying a platinum point is made to contact with a tongue insulated from the body of the machine and connected by insulated wire through a hollow tube to the outside air. By attaching this in circuit with one or more dry cells and a counting device, the revolutions of the meter are recorded. This device attached to a hollow tube of sufficient length can be inserted into the pipe line, as shown in Fig. 1.

This arrangement, in the case of wood pipe, consists of a curved saddle carrying a 6-in. flanged tee which is strapped on the pipe over a 6-in. hole. On this is placed a 6-in. gate valve and above this a chamber or nipple piece provided with flanges at top and bottom. The top is closed with a cover, which carries a stuffing box and gland. The cover and gland cap having been placed on the tube, the meter is inserted into the chamber piece, the cover bolted on and the gland packed. Then the 6-in. valve is opened and the meter pushed down through the disk opening or the valve to the required position. It is, of course, necessary that the device be of proper clearance diameter to pass the valve disk. The gland cap and stuffing box keep the hollow tube in

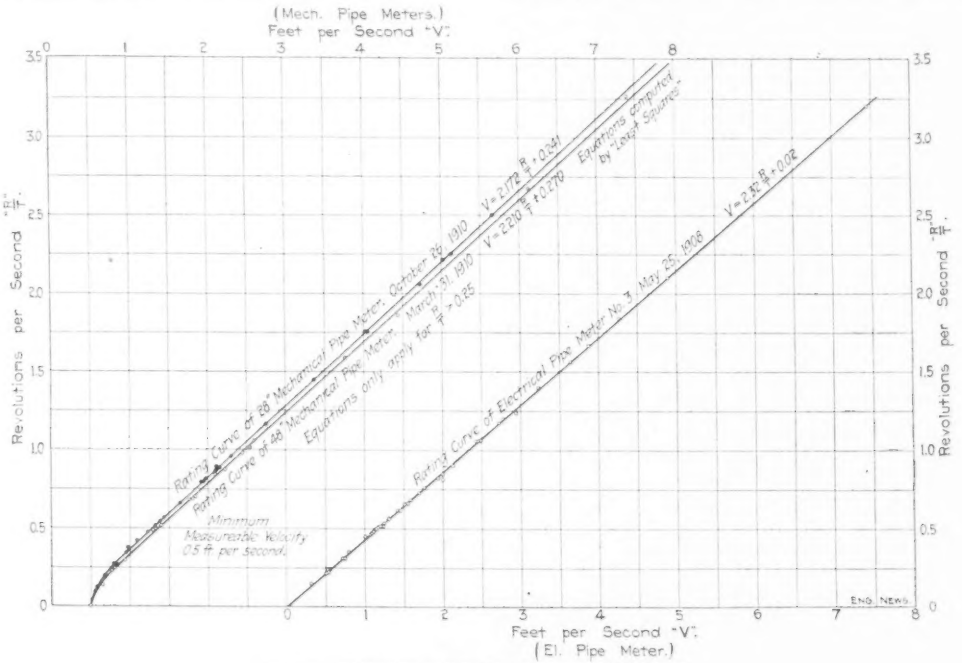
(Mech. Pipe Meters.)
Feet per Second "V."
Revolutions per Second "R/T."
Rating Curve of 28" Mechanical Pipe Meter, October 29, 1910. V = 2.172 R/T + 0.041
Rating Curve of 48" Mechanical Pipe Meter, March 31, 1910. V = 2.220 R/T + 0.270
Equations only apply for R/T > 0.25
Equations computed by "Least Squares"
Minimum Measurable Velocity 0.5 ft. per second.
Rating Curve of Electrical Pipe Meter No. 3, May 25, 1908. V = 2.26 R/T + 0.02
ENG. NEWS.
Feet per Second "V."
(El. Pipe Meter.)

FIG. 2. RATING CURVES OF PIPE METERS.

a vertical position and the tube must have sufficient stiffness to retain, at least approximately that position.

With such a device a velocity curve and coefficient of mean velocity can be experimentally determined for the particular pipe (in a vertical plane only), and the results of flow obtained are to that extent approximate. Some experiments made with a 28-in. pipe line at different rates of flow, where the discharge passed over a carefully

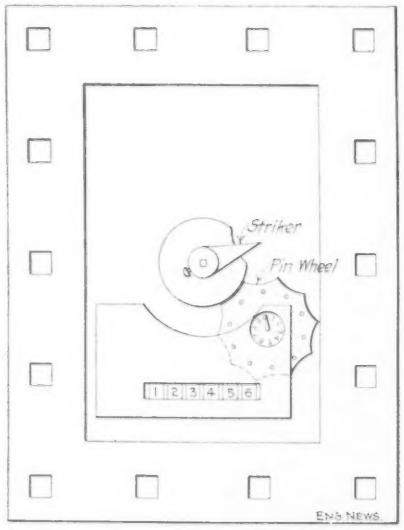

Fig. 3. Striker and Pin Wheel Arrangement for Operating the Counter.

constructed weir, showed a variation between weir measurements and meter measurements of 3% (more or less). Similar vertical velocity curves obtained on a 48-in. wood stave pipe of same character at different rates of flow gave substantially the same coefficient, but we are not able to check as yet against weir measurements of flow.

The meter registers the central velocity in the pipe and the coefficient of mean velocity is taken as 0.89 to 0.91, as determined by a number of tests. In other words, if mean velocity $= Vm$ and central velocity $= Vc$ in a wood stave pipe in clean condition: $\frac{Vm}{Vc} = 0.89$ to 0.91.

The equation of this meter is $V = 2.32 \frac{R}{T} + 0.02$, determined between practical limits of velocity, as shown in Fig. 2.

In practice this device proved unavailable for continuous records owing to the difficulty of maintaining electric contacts, running down of batteries, and certain electrolytic action or corrosion which destroyed the working parts in steady service.

A mechanical meter therefore was constructed, using the same style cups and spindle coupled to a light brass rod extending centrally upwards through a hollow tube attached to a closed box with a cover. The cover contained a plate glass window, intended to be bolted on to the box and made air or water tight by means of a proper gasket. The central rod carries a striker at its upper end and is centered in a bearing, the lower end being carried on a steel pivot as in the ordinary current meter. The striker is made to successively engage with a ten-point pin-wheel geared to an ordinary six-dial counter such as is used in straight reading meters. In this manner the revolutions of the meter are registered positively as long as the water mover with enough velocity to move the cups.

If the total revolutions are read daily, by using the equation of the meter and the proper coefficient of mean velocity, the daily discharge (in cubic feet or gallons) is readily deduced.

Careful tests on our own rating station show that under low velocity too much water passed this meter without being registered, due to the friction of the parts. Efforts were, therefore, made to improve the mechanical construction and reduce the friction coefficient.

A ball-bearing meter was then designed, containing a mechanical device (as shown in Figs. 3 and 4) which prevents jamming or locking between the striker and the ten pins on the driven wheel of the counter. In this device the striker is carried at the top of a light brass rod which is adjustably attached to the upper or movable half of a ball bearing. The latter is of a form to be easily removed from its seat. An upper liner or side thrust ball bearing (not shown) can be used, but it has not proved necessary in practice. The lower end of the brass rod passes through a ball bearing at the bottom of the hollow tube similar to a bicycle pedal, but the rod fits loosely so that it may turn the balls or slip in the hole as conditions warrant. This bearing takes up the side thrust due to the pressure of the water on the meter cups. The latter are removably attached to the brass rod which extends through the end of the hollow tube and by suitable washers and locking nuts, is given sufficient end play. In operation the weight of the cups, washers, nuts, rod, striker, etc., is carried on a bronze ball bearing, and as the whole can be made to weigh only a few ounces, the friction is very small.

Fig. 2 shows the curve and equation of two of these meters. Figs. 3 and 4 show the details of construction as found most practical. It is evident of course that a train of gears would accomplish the purpose of recording the turns of the meter wheel, but it is believed that less friction is produced by using the striker and

*Abstract of a paper read at a meeting of the Western Society of Engineers (Chicago) on May 17, and published by permission of the Society. In a letter accompanying the paper the author gave the following statement as to the origin of the device described:

"This device has been perfected (during my three years' residence in Pueblo) from an experimental stage, to make, I believe, a thoroughly practical machine. Besides myself there have been several parties engaged in perfecting this machine, but all have been in the service of the Colorado Fuel & Iron Co., and I do not think any one person could claim the whole of the design, or sufficient to entitle him to a patent. For this and other reasons I am anxious to have a full description and illustration published, that the engineering profession may receive the benefit of the free use of this device. The firm of W. & L. E. Gurley, Troy, N. Y., has manufactured two of these instruments for me; and J. S. J. Lallie, an instrument maker of Denver, and men in his employ, are also familiar with the general style of the machine."

†Chief Engineer, Colorado Fuel & Iron Co., Pueblo, Colo.

‡Engineering News, April 25, 1907; "Journal of the Western Society of Engineers, August, 1907.

pin wheel (Fig. 3). It is to insure the proper and continuous action of these parts that the special device shown in detail is used, in which there is no friction except at the moment of contact of striker and pin, when the momentum of the parts is utilized. The box being air and water tight can be pumped up with an automobile pump whenever necessary, which keeps out grit or mud and facilitates reading the dials. A blow-off cock enables sediment to be blown out. The box is made of aluminum, and the other parts being very light, the meter is easily handled by one person. All bearings can be kept oiled if desired.

In case the balls, or any parts, wear or corrode, or the water is shut out of the line, the meter can be taken out and, if desired, rerated at a rating station and the new equation determined in a few hours. The same device can be used on an iron pipe of any sort by attaching a tee or other connection large enough for a 6-in. valve opening and a stuffing box connection similar to that shown. The meter can be built for about $100, and the necessary fittings to attach to a wood stave pipe will cost about $50 more. In a cold climate some sort of protection for the meters will be necessary, such as a small brick house heated by some means in very severe weather. The house will cost about $300, making the total outfit cost $600 for two meters. In case a permanent automatic record is desired, an electric recording device can be attached in a similar manner to those furnished by several well-known manufacturers.

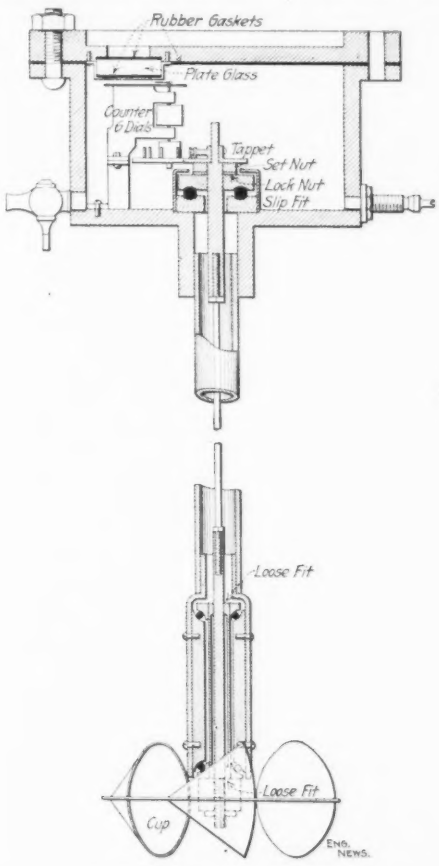

Fig. 4. Ball-Bearing Meter of the Current Meter Type for Measuring the Flow of Water in Large Pipe.

It is interesting to note that the mean velocity in wood stave pipe is here shown to be 90% of central velocity, while reference to the Proceedings (1907) of the American Water Works Association* shows that in large cast-iron pipes this coefficient ranges from 80% to 85%.

A STEAMER EQUIPPED WITH CONVEYORS for discharging coal and ore cargo is being built by Doxford & Co., of Sunderland, England. The vessel will be 350 ft. long, with capacity for 3,750 tons of cargo. Under the holds will be slow-speed conveyors, consisting of pressed steel plates attached to wire ropes which pass over 4-ft. driving sheaves. The discharging end can be given any desired inclination. The capacity of the conveyors is from 500 to 800 tons per hour. The cost of discharging (including the operation of the driving engine) is estimated at ½ ct per ton. A lake steamer having belt conveyors for discharging its cargo of broken stone was described in our issue of Jan. 19, 1905, and there are on the Great Lakes two or three steamers similarly equipped for discharging coal and ore.

*Edw. S. Cole, "The Pitometer and Water Works Losses," page 136.

Standardized Street Widths.*

By JOHN NOLEN.†

If we are to remedy the municipal ills from which we now suffer some large physical changes in American cities are absolutely necessary and inevitable. Nevertheless, permanent progress in city planning will not result usually from spectacular schemes for the sudden transformation of our cities, nor from revolutionary programs and proposals. Advances will come more often from a patient but open-minded and scientific study of such problems as are represented by the title of this paper, followed by a close coordination of one subject with another in a comprehensive plan, thus recognizing the unity of the city and the inter-relation of all its parts.

It would not be difficult to convince any one not already convinced—if such there be—of the importance of fixing street widths more intelligently and discriminatingly. At the present time an average of 20 to 40% of the total area of cities is devoted to streets, rising in the case of Washington, D. C., to 54%. Therefore, even a slight variation in the width of the streets of a city becomes a matter of importance. Consider, for example, what an excess of 2 ft. in the width of the 1,400 miles of paved streets of Philadelphia would involve in the cost of land and paving! On the other hand—and here the lack of intelligent and discriminating action has even graver aspects—consider what the *lack* of a few feet in the width really necessary for streets in Philadelphia already involves! It involves directly the expenditure of enormous sums of money for street widening or, indirectly, of much greater sums, practically incalculable in amount, as the penalty for conditions which still appear to our too timid minds virtually unchangeable.

The evils of the present system of fixing street widths are acute. They demand prompt but careful examination and correction. What, then, are the causes of the existing difficulties in this matter of street widths and what are the remedies? Some students of this subject are of the opinion that the evils are due, in part at least, to a standardization of street widths; to the fact that city councils or other municipal authorities have heretofore fixed upon a certain number of feet, usually 40, 50 or 60 ft., as the width for all streets. Undoubtedly such action has proved a handicap to many a city. But is the standardization itself the evil? Is it not the arbitrary and unintelligent character of that standard; and is not the remedy another standard, or other standards, rather than the abandonment of the principle of standardization? Is there not danger of reacting too far, or of reacting in the wrong direction? The remedy for a stupid standardization of street widths is not likely to be found in the abandonment of all standards, but in the adoption of more intelligent standards.

It would seem that street widths could be satisfactorily standardized because the facts upon which such widths rest are capable of definite classification and, furthermore, because it is practicable to collect scientific data concerning these facts and from this data to reason to sound conclusions with a considerable degree of confidence. While these facts are numerous and varying, they are not more so than those connected with the cutting of metals or some of the other operations that have been so successfully standardized in the industrial world in recent years.

What are the facts which should determine street widths? They are (1) the width required for "a line of vehicles," thus fixing roadway units; (2) the width required for "a line of pedestrians," thus fixing sidewalk units; (3) the classification of the streets of a city according to the traffic requirements put upon them, or the other functions that they are to serve; and (4) an estimate of the present and future traffic of the streets of any given class, the width required to meet that traffic, and then the standardization of that width.

(1) It is not yet possible to fix with scientific accuracy the width required for a line of vehicles, partly because the data as to the actual average width of present-day vehicles is inadequate, and partly because that width is just now in process of change, due mainly to the increasing size and use of the motor truck. Nevertheless, the conclusions on this point are already fairly definite. The difference is represented by about one foot. One set of investigators holds that 9 ft. or thereabouts should be fixed as the width required for a line of vehicles. They base their opinion upon the fact that some motor truck bodies to-day have a width of 8 ft. and that the tendency of manufacturers is to increase the width of trucks. The margin for safe clearance, taking into account average skill in driving, would require about another foot for each line of vehicles, making the total width 9 ft. Other investigators find that to-day very few vehicles, even large motor trucks, measure more than 6½ or 7 ft. in width, and that conditions of construction or laws are likely to place a limit upon advantageous width close to 7 ft. This view has the support of some of the vehicle companies who hold, in the interest of the manufacturer and user of trucks, as well as the public, that 6½ or, at most, 7 ft., should be the maximum width.

It is not the purpose of this paper to try to settle finally the width required for a line of vehicles or, to settle any other fact or specific point connected with the standardization of street widths. The purpose is merely to indicate the advantages and necessity for such standardization and to suggest some reasonable basis for it.

But to apply further the method suggested above, we may assume, for the sake of making the application definite, that a width of 8 ft., the present working figure of many of the best practitioners, is sufficient for a line of vehicles. As a matter of fact, not only the width of vehicles but also the load is likely to be standardized by law, so that the engineer, landscape architect, or city planner will have a definite maximum figure to work with. These limits may have exceptions, but the exceptions should be discouraged by a vehicle license tax, which would increase very rapidly on vehicles above certain dimensions.

In addition to the space required for vehicles, allowance must be made on many streets for electric cars. Assuming double tracking, which is the most economical method usually, this allowance should be not less than 20 ft.

(2) Various methods have been devised and followed for determining the width of sidewalks. The most customary is to make the sidewalk some fixed proportion of the roadway. In some cases, following this method, each sidewalk is one-half the width of the roadway; in others one-third the width of the roadway. The latter appears to represent the most frequent practice. This method, however, appears arbitrary and, in some instances, would be unsound, because the use of the sidewalks does not necessarily increase and diminish with the amount of traffic on the roadway. However, the custom of making the sidewalk one-third the width of the roadway has proved fairly satisfactory in practice: for example, in the subdivision of a 100-ft. business street into a 60-ft. roadway and 20-ft. sidewalks. Fixing the width for a line of pedestrians at 2 ft., if the application of the principle to pedestrians does not appear too academic, this allows, on a street with a total width of 100 ft., for ten lines of pedestrians on each of the 20-ft. sidewalks. The proper width of sidewalks, the method of determining that width, and a more rigid control of encroachments upon sidewalks, all deserve more attention than they have heretofore received.

(3) The classification of the streets of a city according to the traffic requirements put upon them or the other functions that they are to serve is, of course, one of the fundamental requirements of any attempt to standardize street widths. European countries have made such classifications. Here are the figures for some of the cities of England and Germany:

The London Traffic Commission made five divisions as follows:

Main avenues	140 ft.
First class arterial streets	100 "
Second class streets	80 "
Third class streets	60 "
Fourth class streets	40 to 50 ft.

No street was to be less than 40 ft. This standard classification, applying to London and its suburbs, is a great advance over the London Building Act of 1894, which put the average width of streets "in the public interest" at 40 ft. clear or 20 ft. from the center of the roadway to the nearest external wall; and the Council could not require a greater width than 60 ft.

The standard classification for German cities of the second size, cities like Leipzig and Frankfort, is as follows:

Main thoroughfares	85 to 118 ft.
Secondary thoroughfares	50 to 80 "
Local streets	35 to 47 "

A Prussian law, in force since 1875, apparently drawn to meet the requirements of Berlin, fixes the following dimensions for the laying out of new streets and for the alteration of old ones:

Main thoroughfares	95 ft. or over
Secondary thoroughfares	65 to 95 ft.
Local streets	40 to 65 "

The width of streets in different American cities varies greatly. There are very few that have adopted standards for the classification of streets according to traffic requirements. Probably the best classification is that of Washington, D. C., which is as follows:

Main thoroughfares	160 ft.
Secondary thoroughfares	120 "
Local streets	60 to 90 ft.

The German city standards, given above, appear to be more reasonable and logical than those of London or Washington, and there is a distinct advantage in having more or less range within each classification, as against fixing the width hard and fast to a single figure. It ought to be practical to classify most of the streets of a city either as main thoroughfares, secondary thoroughfares, or local streets, and to apply to them one of the standard widths adopted for their respective classifications.

(4) To determine such classification, however, requires an estimate of the recent and future traffic requirements of the streets of any given class. It does not seem wise

*A paper read before the Third National Conference on City Planning, Philadelphia, May 17, 1911.

†Landscape Architect, Cambridge, Mass.

to begin by fixing the width of a street at say 50 or 60 or 100 ft., and then apportioning that width as favorably as may be between roadway and sidewalk. It is better to begin at the other end and try to decide what traffic capacity in roadway and sidewalk the street should provide for, thus determining which class it falls in; and then, applying the unit of measurement adopted for car lines, for vehicles, for pedestrians, for trees, etc., decide upon the required width. For example, here are three illustrations of this method:

I. An *average main thoroughfare* is to have, say,

a double track car line	20 ft.
6 lines of vehicles, 3 on each side of tracks 8 ft. each	48 ft.
20 lines of pedestrians, 10 lines on each of the two sidewalks, 2 ft. each	40 ft.
Total for an average main thoroughfare	108 ft.

II. An *average secondary thoroughfare* is to have, say,

a double track car line	20 ft.
4 lines of vehicles, 2 on each side of tracks, 8 ft. each	32 ft.
16 lines of pedestrians, 8 lines on each of the two sidewalks, 2 ft. each	32 ft.
Total for an average secondary thoroughfare	84 ft.

III. An *average local street* is to have, say,

Roadway for 3 lines of vehicles, 8 ft. each	24 ft.
12 lines of pedestrians, 6 lines on each of the two sidewalks, 2 ft. each	24 ft.
Total for an average local street	48 ft.

These are only averages and are given simply as illustrations of the method of standardization proposed and its application. The range of street widths for such a classification might be as follows:

Main thoroughfares	from 90 to 180 ft.
Secondary thoroughfares	from 60 to 90 ft.
Local streets	from 40 to 60 ft.

Such a standardization would naturally differ from city to city as conditions and requirements differed. Its advantages would be twofold; first, in fixing the range of normal street requirements of three or more important classes; secondly, in definitely and consciously trying to determine in advance to which class a particular street belonged. Of course, even with such a classification there would be many, many exceptions—special streets having special requirements and, therefore, calling for special provisions. But if no standards whatever are fixed—and this is the important practical point—there is danger that the normal differentiation of the streets of one class from those of another will be constantly overlooked, or that private interests through pressure and influence may succeed in securing action which is in conflict with the public requirements. It was largely to prevent these results that street-width standards, in most case unintelligent and undiscriminating, were adopted by cities in the past. Where no standards whatever have been adopted many illustrations can be found of the abuses that have crept in, particularly the failure to allow sufficient street width for main and secondary thoroughfares.

In the discussion thus far, no reference has been made to trees, grass strips or other planting in the streets or of space set aside primarily for the adornment of the street or for insuring the benefits of light and air and an appearance of spaciousness. Such reference was omitted merely to simplify the subject and bring it within the compass of a brief paper. Of course, trees are desirable not only in residence streets, but also in most business streets. Of the many arguments against the greater use of trees in our business streets, the only sound argument in most instances is that there is no room for them. But as with traffic so with trees. The same method should be applied. If we are to have trees we must determine the width requirements of a line of trees or two lines of trees or whatever else is needed. Except for temporary effects, it is not good policy to plant trees in a space that is needed for roadway or sidewalks; nor is it good policy to plant one or more lines of trees in a space that is inadequate for their successful growth. If, for instance, it is decided that 6 ft. is the minimum space in which a line of trees of a given species can flourish, then we should standardize that width for that species of tree and provide it. Exceptions there would be undoubtedly to standards for trees, as for roadways and sidewalks, but they would be recognized as exceptions and justified because of exceptional conditions. Standards can only be applied profitably to the normal, but in such matters as street widths, five-sixths, perhaps nine-tenths, of all cases would be normal.

The traffic and use of many city streets increase from year to year, tending to shift some streets from one classification to another. How to provide a method of meeting this increase is a difficult question to answer. To begin with, we must recognize that a city that is alive has growth, and that growth makes changes from time to time necessary. Street widths cannot be made right "once for all." The utmost foresight must be exercised and then adjustments and widenings made to meet new conditions. Street development, like most other features of city planning, is an unending process. In the field of education, the unending character of the process was expressed by the boy who inquired at a public library for a book which, he said, was entitled "How to Get Educated and How to Stay So." So it is with streets. The problem is how, by the exercise of skill and foresight, to design and arrange them to fulfill their functions and then from time to time how to re-design and re-arrange them to meet new requirements. In the case of streets where increased traffic is expected, the most practical method of providing for it, perhaps, would be to reserve some extra space between the roadway and sidewalk, or in the center of the roadway, or between the sidewalk and the buildings, utilizing this space temporarily as an area planted with trees and shrubs or merely with grass.

The evils that might follow from the adoption of an undiscriminating set of standards or from an unintelligent application of a discriminating set, have not been overlooked. They might be serious. But it is my opinion that under our present city organization such evils would ordinarily be less than those that almost inevitably follow from a lack of any established standards and from the policy of determining street widths piecemeal as each is presented for decision.

A HOISTING ENGINE'S BOILER EXPLODED at Chicago, May 19, and nine men were injured, none seriously. The engine was in use for sinking the wells for the foundation piers of the new Otis Building at La Salle and Madison Sts., and as this is in one of the busiest parts of the city there were a number of narrow escapes from injury by flying debris. There are numerous small boilers of this kind in use on building construction work in the business district and the accident is expected to lead to an investigation as to their condition.

THE STEAMSHIP "MERIDA" of the Ward line, with 207 passengers bound from Havana, Cuba, for New York City, was sunk May 12 by collision with the steamer "Admiral Farragut," bound from Philadelphia for Port Antonio. The collision occurred off Cape Charles, shortly after midnight. The "Merida" remained afloat for five hours after the collision. This gave time for the transfer of her passengers and crew in open boats to the "Admiral Farragut," which had suffered only relatively slight damage to her bow. The steamer "Hamilton" of the Old Dominion line and the U. S. Battleship "Iowa" came in response to wireless telegraph messages and the "Merida's" passengers were transferred from the "Admiral Farragut" to the "Hamilton" and taken to Norfolk.

A BAD BREAK IN THE ERIE CANAL just east of Rochester on May 19, will result in at least a three weeks' delay in the opening of the canal for navigation. The break occurred on the so-called "Ten-Mile Level" between Pittsford and Bushnell's Basin at a place where the side walls of the canal had been torn down and replaced in the construction of the adjoining Barge Canal. Damage to the extent of some thousands of dollars was done by the water tearing through the 150-ft. opening and wrecking surrounding houses and railway bridges and embankments.

ELECTRIFICATION OF THE BROAD ST. TERMINAL line of the Pennsylvania R. R. in Philadelphia is contemplated, according to press reports. It is proposed to have all trains drawn by steam locomotives start from the West Philadelphia station where through trains now stop without going into Broad St. The station at Broad St. will thus become a terminus for a heavy suburban traffic with trains operated chiefly on the multiple-unit system.

THE CHICAGO SUBWAY SYSTEM for street cars and the trains of the elevated railways is to be built and owned entirely by the city, according to the policy adopted by Mayor Harrison and the new city administration. The traction ordinances of 1907 provide that the street railway companies may be required to contribute $5,000,000 towards subway construction (Engineering News, March 10, 1910), but it is considered that this might involve some element of partnership, or part ownership by the companies. The administration, as represented by the council committee on local transportation, favors absolute municipal ownership of the subways. The work would be paid for out of the traction fund, and would be limited by the amount of funds available. The fund now amounts to about $6,000,000, and is increased by about $1,500,000 per year. A series of public hearings on subway plans will be held by the committee, and three plans will be described by the engineers who have prepared them; these are the plans of Mr. B. J. Arnold, M. Am. Soc. C. E., Chairman of the Board of Supervising Engineers; Mr. John Ericson, M. Am. Soc. C. E., City Engineer, and Mr. Geo. W. Jackson.

RADICAL CHANGES IN THE WATER-SUPPLY AND sewage disposal of Milwaukee, Wis., are recommended in a report by a commission consisting of Messrs. John W. Alvord of Chicago, Geo. C. Whipple of New York, and Harrison P. Eddy of Boston, all Members of the American Society of Civil Engineers. The report was submitted to the Common Council on May 4, 1911, through Mr. Emil Seidel, Mayor of Milwaukee. It advises: (1) Immediate filtration of the water-supply, with disinfection when necessary; estimated cost, $1,500,000. (2) Flushing works for the Menominee River, to be completed by 1915, at an estimated cost of $1,162,000. (3) High-level and low-level intercepting sewers to divert sewage from the rivers; certain low-level interceptors, in addition to those now in use to be built first at an estimated cost of $809,000, and extensions to be made as necessary; the high-level interceptors to be left for future construction, when it becomes necessary to relieve the low-level. (4) A sewage pumping plant to handle the low-level sewage, to be ready for use by 1915; estimated cost, $669,000. (5) Sewage sedimentation tanks and accessories, for the clarification and disinfection of the sewage, to be ready in 1915; estimated cost of plant sufficient until 1930, $754,000. (6) Temporary discharge of sewage into the Kinnickinnick River, but the construction for use as early as 1920 of an outfall sewer with multiple submerged outlets into Lake Michigan "at regular intervals from 1 to 1⅔ miles from the shore; estimated cost, $2,113,000. (7) Percolating filters at the lake shore, and the transfer of the disinfection works to that point are advised "as soon as it may be necessary" to further purify the sewage; estimated cost, with capacity sufficient until 1930, $1,866,000. The expert engineers found "that the waters of the bay are polluted by the sewage of the city and that at times the water-supply is contaminated"; that topographical conditions make it necessary to continue the use of the lake for sewage-disposal purposes; that the intercepting sewers will not keep *all* sewage out of the rivers and lake,

especially in times of storm, and the effluent from the sewage works will cause some bacterial contamination of the waters of the bay and will at times endanger the water-supply.

At the same time it was also concluded:

That the filtration of the water-supply, with disinfection where necessary, is the most efficient and economical means of assuring its purity, and that sewage purification should be carried on only so far as to prevent undue contamination of the rivers and bay.

BY THE FALL OF A MONOPLANE FLYER from a height of 250 ft., Lieut. Paul Dupuis of the French Army and one Pierre M. Bournigue were killed, at Rheims, on May 18. The machine capsized in a squall and was burned after the accident. On May 23, an aviator named Laemmlin fell 200 ft. at an aviation meet in Strasburg, Germany, and was killed.

At the start of an aeroplane race from Paris, France, to Madrid, Spain, on May 21, a flyer got beyond control of an aviator and dashed into a crowd, killing the French Minister of War, Henri M. Berteaux, and injuring the Minister of the Interior, Antoine Monis, his son and Henri Deutsch de la Meurthe, the well-known patron of aviation contests.

In spite of this accident the race was started, with four competitors. On the first leg of the course, from Issy-les-Molineux, to Angoulême, 279 miles, a new world's time-distance record of 3 hrs. 43 min. was established by Pierre Vedrine. Two other aviators covered the first leg and Vedrine reached San Sebastian, Spain, on May 23.

A TELPHERAGE BAGGAGE-HANDLING SYSTEM has been devised by Mr. John A. F. Aspinall, General Manager of the Lancashire & Yorkshire Ry. (England), and is in use at the Victoria Station in Manchester. The electric trolley hoist is equipped with a motor of 1½ HP., and is designed to handle a load of 1,100 lbs. It is 2 ft. 7 ins. long, or 4 ft. including the operator's seat, and the trolley has four 10-in. wheels riding on two rails 11¼ ins. apart; the wheelbase is 11½ ins. One pair of wheels is driven by the motor, and the wheels are connected by coupling rods. The rails are carried by the side legs of rectangular hangers which are suspended from the roof framing, the trolley passing through the hangers. The hoist carries a basket 5½ x 3 ft., and 33 ins. deep, in which the baggage is placed. This basket has small wheels which enable it to be moved easily. The weight is as follows: Machine, 605 lbs.; motor, 216 lbs.; basket, 362 lbs.; operator (boy), 100 lbs.; total, 1,286 lbs. The speed is 5 m. p. h. for traveling and 24 ft. per min. for hoisting. The total length of travel is 2,448 ft.

WATER TANKS LOCATED ON THE ROOF or external part of buildings in New York City must hereafter be tightly covered or else provided with an extra fine-mesh screen to prevent the access of mosquitoes to stored water. In addition, such tanks must be ventilated and where the water is for general use they must be emptied and the inside thoroughly cleaned at least twice a year, and at such other times as may be directed by a designated city health official. The provisions just cited have recently been added to the Sanitary Code of the Department of Health of the City of New York.

BOILER, ELEVATOR AND FLYWHEEL ACCIDENTS in the United States and Canada during the month of February, 1911, are listed in bulletins issued by the Fidelity & Casualty Co., of New York. The total number of persons killed in all three classes of accidents in that month was 47, of whom 24 were killed by boiler explosions and 23 by elevator accidents. There were only 19 boiler explosions—about half the average number for the preceding four months—and yet the number of fatalities was only slightly below the average, due to the coincidence of three explosions which together killed 19 persons. The most severe of these, in which 10 persons were killed, was that at Smithville, Tex., Feb. 8, briefly noted in Eng. News of Feb. 16. The total number of elevator accidents was 82, but only eight of these involved the falling of elevators and none of the accidents in which elevators fell resulted fatally. Of the 23 persons killed in elevator accidents, 13 fell down shafts and 10 were caught and crushed between elevator and building. Five "flywheels" (three of which were emery wheels) burst during the month but caused no fatalities.

LAKE AND RIVER STEAMERS for Canadian service, both for passengers and freight, are being built in England in increasing numbers. One of the latest is of the typical American passenger steamer design, with low hull and high superstructure. This is the "Saguenay" for the Richelieu & Ontario Navigation Co.'s service on the St. Lawrence and Saguenay rivers. It is 275 ft. long, 56½ ft. beam, and 40 ft. deep from the hurricane deck. It has five decks, three of which are above the main deck upon which the superstructure is built. The twin screws are driven by two triple-expansion four-crank high-speed engines. Steam is supplied by three boilers carrying 175 lbs. pressure and fitted with the Howden hot draft system. The steamer will carry 1,700 passengers and a crew of 76, and has sleeping accommodation for 240 first-class passengers. For the ocean voyage the sides will be boarded in from the main deck to the next deck above. This steamer and its engines were built by the Fairfield Shipbuilding & Engineering Co., of Glasgow, Scotland. It was launched April 27.

BREAKING CONCRETE BY HYDRAULIC JACKS is a novel character of work employed in harbor improvement work at Fleetwood, England. To deepen the channel connecting the docks it was necessary to remove a mass of concrete about 50 ft. long, 10 ft. wide and 17 ft. deep, forming the old sill. The site was laid dry by means of cofferdams, and girders laid across the opening carried a traveling platform fitted with a drilling rig. The cutter was a steel tube 17¾ ins. diameter and ⅜-in. thick, boring annular holes by means of chilled steel shot. The average rate of progress was 1 in. in 11 mins. When the required depth was reached, gravel was poured to bind the core to the tube, and a combined side pressure and upward pull sufficed to break off the core, which was then pulled out. After a number of holes had been drilled, horizontal hydraulic jacks were inserted; the end of the cylinder being rounded to fit the wall of the hole, while a block with its face similarly rounded was fitted to the plunger. These jacks could exert a pressure of 275 tons, and easily burst the concrete. The largest block thus loosened weighed about 9 tons. The contractors for this work were A. C. Potter & Co., of London, England.

Personals.

Mr. W. E. Winn, until recently City Engineer of Danville, Ill., has opened an office in that city for the private practice of engineering.

Mr. F. K. Carey has resigned as President of the City Planning Commission of Baltimore, Md., because of the pressure of other business.

Mr. Rhinelander Waldo, Fire Commissioner of New York City, has been appointed Police Commissioner. Mr. Waldo is an ex-army officer and has previously served the city as a Deputy Police Commissioner.

Mr. J. H. H. Muirhead, Assistant Engineer of the Port of Para, Brazil, has resigned that position to become Consulting Engineer for La Campañia de los Puertos de Cuba. He will make his headquarters at Havana.

Mr. John S. Runnells has been elected President of the Pullman Co., succeeding Mr. Robert T. Lincoln, whose resignation was recently noted in these columns. Mr. Runnells was formerly Vice-President and General Counsel.

Mr. Raymond A. Walter, formerly Assistant Engineer of the Maryland Division of the Consolidated Coal Co., has been appointed Chief Engineer, succeeding Mr. L. B. Abbott, who has been transferred to the Elkhorn Division of the same company.

Lt.-Col. B. W. Dunn, hitherto connected with the Ordnance Department of the U. S. A., has resigned his commission in order that he may continue his work as Chief Inspector of the Bureau of Explosives of the American Railway Association.

Mr. Henry C. Adams has resigned as the head of the Division of Statistics and Accounts of the Interstate Commerce Commission, which position he has held since August, 1906. He is succeeded by Mr. Chas. A. Lutz, now Chief Examiner of Accounts.

Mr. Edwin Main, Chief Engineer of the Rockford & Interurban Ry., at Rockford, Ill., has resigned this position in order to accept that of City Engineer of Rockford. He held this latter position for some years previous to taking up railway work.

Mr. Charles J. Poetsch, M. Am. Soc. C. E., for 12 years Engineer of the municipal water-works and city engineer of Milwaukee, Wis., has associated himself with Mr. G. A. Geiger, under the firm name of Poetsch & Geiger, for business as civil and consulting engineers, with offices in the Mack Bldg., Milwaukee.

Mr. Edward W. Bemis, formerly Deputy Commissioner of the Department of Gas, Water Supply and Electricity of New York City, has been engaged by the city of Toledo, Ohio, to make a valuation of the Toledo street railways, as a preliminary to negotiations between the city and the company for a renewal of the franchise.

Mr. U. L. Leonhauser has been employed as expert accountant for the Herman A. Metz Fund to Promote Efficient Municipal Accounting and Reporting. This fund amounts to $10,000 a year for three years, and is to be administered by the Bureau of Municipal Research, New York City. Mr. Geo. L. Bergen, an expert accountant connected with the Bureau, will be associated with Mr. Leonhauser.

Mr. Charles C. Moore, of the engineering and contracting firm of C. C. Moore & Co., of San Francisco, Cal., has been chosen the executive head of the Panama-Pacific International Exposition to be held in that city in 1915. It is announced that the organization for this exposition will differ essentially from those of previous world's fairs. Mr. Moore as the executive head will be entrusted with the responsibility of carrying out every detail. He will have the appointment of all officers and department heads and each chief will be directly responsible to him. The whole affair will be organized and conducted like a great business corporation.

Prof. Harold B. Smith, M. Am. Inst. E. E., Director of the Department of Electrical Engineering at the Worcester Polytechnic Institute, has been granted a two years' leave of absence, beginning July 1, 1911. Prof. Smith expects to spend one year in travel in Europe, Asia, Japan and the Philippines, and the other year in special resident study at Berlin and Zurich, and in the investigation of European educational and engineering institutions. This leave of absence follows 15 consecutive years as the head of the department at the Institute, during which time he has also carried on an extensive consulting practice. Prof. Smith is also a member of the Institute of Electrical Engineers of Great Britain and was Chairman of the International Group Jury of Awards in electrical engineering at the St. Louis Exposition in 1904.

A statue of the late John Miffin Hood, for many years President of the Western Maryland R. R., was unveiled in the city of Baltimore, Md., on May 11. The statue, which is a bronze figure of heroic size, was erected by the city as a memorial to a man whose public spirit and whose ability not only saved Baltimore from a severe financial loss, but made possible a profit to the city from a railway line which at one time was regarded as almost worthless. The Western Maryland R. R. was incorporated in 1852 and its construction begun in 1857. Liberal aid toward its construction was given by the city of Baltimore and by Washington County. The total amount invested by the city was in the neighborhood of $9,000,000, represented by stock and other securities owned, deeds for realty, direct loans by the city and interest paid on guaranteed bonds. For years the enterprise languished. The traffic of the railway was insignificant and the investment the city had made was generally supposed to be totally lost. It was in this situation that Mr. Hood was placed in charge of the road as President, and he determined to try and save the property for the city. He rebuilt the road, planned and constructed extensions and branches which brought it a profitable traffic, and made the railway of such strategic importance that in 1902 he was able to sell the city's interest in the property at a large profit over its investment.

It was in recognition of this disinterested and able public service that the city of Baltimore has erected the monument.

Obituary.

Arthur Postley, an engineer with the Consolidated Gas Co., of New York City, died in that city on May 16. He was 46 years old and had been in the employ of the company for many years. He was a member of the Engineers' Club of New York.

Ralph Crammer, a designing engineer with the Public Service Commission of New York, died at his home on Staten Island, N. Y., on May 18. He was born in Tucherton, N. J., in 1866 and graduated in civil engineering from Lafayette College in 1888. He was formerly employed with the Board of Rapid Transit Commissioners, and had been with the Public Service Commission since 1909.

Charles F. Choate, former President of the Old Colony R. R., died at his home in Boston, Mass., on May 23, aged 83 years. He was a gradute of Harvard University and for many years a lawyer of Boston. He was President of the Old Colony R. R., now part of the New York, New Haven & Hartford R. R., from 1878 to 1907. He was a member of the corporation of the Massachusetts Institute of Technology.

Daniel H. Newton, a prominent contractor and builder of Holyoke, Mass., died in Brookline, Mass., on May 19. He was the founder of the firm D. H. & J. C. Newton, of Holyoke, and was for many years a builder of paper mills and other manufacturing plants throughout Western Massachusetts. Mr. Newton was also financially interested in many manufacturing concerns and was the organizer and President of the Hoosac Tunnel & Wilmington R. R.

Henry H. Sykes, Assoc. Am. Inst. E. E., General Manager of the Southern New England Telephone Co., died in New Haven, Conn., on May 19. He was born in Suffield, Conn., in 1867. He graduated from Sheffield Scientific School, Yale University, in 1889, and from the Massachusetts Institute of Technology in 1891. He was employed by the American Telephone & Telegraph Co. until 1895, when he became Chief Engineer of the Bell Telephone Co. of Missouri. In 1902, he went to New Haven as General Superintendent of the Southern New England Telephone Co., and in 1907 was made General Manager.

Engineering Societies.

COMING MEETINGS.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 29-June 2. Annual convention at New York City. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 30-June 2. Annual convention at Pittsburg, Pa. Secy., Calvin W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
June 6-10. Annual convention at Glen Summit Springs Hotel, Luzerne Co., Pa. Secy., Joseph Struthers, 29 West 39th St., New York City.

AMERICAN WATER WORKS ASSOCIATION.
June 6-10. Annual convention at Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ENGINEERS' SOCIETY OF PENNSYLVANIA.
June 7-10. Annual meeting at State College, Pa. Secy., E. R. Dasher, P. O. Box 704, Harrisburg, Pa.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
June 19-23. Annual convention at Boston, Mass. Secy., Joseph Jacobs, 803 Central Bldg., Seattle, Wash.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 13-16. Annual convention at Chattanooga, Tenn. Secy., Charles W. Hunt, 220 West 57th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-16. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 19-21. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-23. Annual Convention at Boston, Mass. Secy., P. W. Drew, M., St. P. & S. S. M. Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 21-24. Semi-annual meeting at Chicago, Ill. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 26-30. Annual convention at Chicago, Ill. Secy., Ralph W. Pope, 33 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 27-29. Annual meeting at Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN CHEMICAL SOCIETY.
June 28-July 1. Annual convention at Indianapolis, Ind. Secy., Charles L. Parsons, Durham, N. C.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 25-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—The next convention will be held at Newark, N. J., June 28-30.

CENTRAL RAILWAY CLUB.—At the regular meeting at Buffalo, N. Y., May 12, Mr. G. K. Heyer, of New York City, presented a paper on "Train Despatching by Telephone."

ENGINEERS' CLUB OF TORONTO.—The equipment of a social club has been added this year to the library and lecture room and the club is developing social features in addition to the strictly technical activities.

NATIONAL FIRE PROTECTION ASSOCIATION.—The report of Secy. Franklin H. Wentworth at the annual meeting in New York City, May 23, announced a gain of 408 in the total membership of the association. The total membership is now 1,955.

ENGINEERS' CLUB OF ST. LOUIS.—At the regular meeting of May 17, an illustrated paper on "The Sand Drying Plant of the United Railways Company" was presented by Mr. C. L. Hawkins, Engineer of the Track Department of that company.

NEW YORK RAILROAD CLUB.—At the meeting of May 19, in New York City, Prof. J. M. Moorehead, of Chicago, presented a paper on "The Possibilities of the Oxy-Acetylene Torch in the Railroad Shop." The paper was illustrated by practical demonstrations.

THE CLEVELAND ENGINEERING SOCIETY.—At the meeting of May 23 a paper on "Some Recent Improvements in Electric Motor Control" was presented by Mr. Claiborne Pirtle, Vice-Pres. of the Electric Controller & Mfg. Co. The annual meeting will be held June 13.

NATIONAL HOUSING ASSOCIATION.—The first National Conference on Housing in America will be held in New York City June 3-6. The program includes some papers of interest to sanitary engineers. The Secretary is Mr. John Ihlder, 105 East 22nd St., New York City.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—At the meeting of May 24 Mr. Lazarus White presented a paper entitled "Construction of the Rondout Pressure Tunnel of the Catskill Aqueduct." A visit of inspection to the New York Botanical Garden will be made on June 17.

UTAH SOCIETY OF ENGINEERS.—At the meeting of May 19 at the University of Utah, Mr. George F. Bacon presented a paper entitled "Notes on the Construction of a Large Concrete Diverting Dam." The new President, Mr. Grosh, was introduced by the retiring President, Mr. Honnold, and gave his inaugural address.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—The annual meeting will be held in Washington, D. C., beginning on Dec. 27, 1911, under the presidency of Dr. Charles E. Bessey, of the University of Nebraska. The permanent secretary is Mr. L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The graduates of the Worcester Polytechnic Institute who attend the spring meeting at Pittsburg, May 30-June 2, are invited to an informal dinner which will be given by the Pittsburg Alumni Association of that Institute at the Fort Pitt Hotel on Monday evening, May 29.

MAINE SOCIETY OF CIVIL ENGINEERS.—A meeting was held at Waterville, Me., May 23, at which papers were presented as follows: "Investigations of the Water Resources of Maine," Cyrus C. Babb, District Engineer, U. S. Geological Survey; "Results of Experiments on Ice Action," Walter H. Sawyer, Union Water Power Co.; "Special River and Lake Surveys," Prof. H. S. Boardman, University of Maine.

ENGINEERS' SOCIETY OF NORTHEASTERN PENNSYLVANIA.—This is the new name of the society formerly known as the Scranton Engineers' Club. The change was made because the membership is drawn from the entire northeastern part of the state and not from Scranton alone. The society's rooms are at 302 Board of Trade Bldg., Scranton. The secretary is Mr. H. S. Webb, 1504 Capouse Ave., Scranton, Pa.

NEW YORK AND CHICAGO CEMENT SHOWS.—It has been announced by the Cement Products Exhibition Co., of 72 West Adams St., Chicago, that the second annual New York Cement Show will be held in Madison Square Garden Jan. 29-Feb. 3, 1912, and that the fifth annual Chicago Cement Show will be held in the Coliseum, Chicago, Feb. 21-28, 1912. The determination to continue these shows was the result of a letter ballot taken among exhibitors at previous exhibitions.

NATIONAL ELECTRIC LIGHT ASSOCIATION.—At a recent meeting of the Executive Committee in New York City it was announced that more than 1,800 new members had been admitted since the last meeting—about two months ago—and that the total membership at the present time was 8,100. The association has about $40,000 in cash and securities and no outstanding debt. The special committee, of which Mr. John F. Gilchrist is Chairman, reported on its trip to the Pacific Coast to inspect the facilities of various cities with regard to the proposed convention of 1912, and it was decided to hold the next convention at Seattle, Wash., probably early in June, 1912.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Among the papers to be presented at the third semi-annual meeting at Chicago, June 21-24, are the following: June 21—Report of Committee on Chemical Engineering Education, Dr. Samuel P. Sadtler, Chairman. June 23—"Industrial Chemical Calculations," Prof. Jos. W. Richards; "Distillation on the Continuous System," and "A New System of Lead and Silver Lining for Chemical Apparatus," Charles L. Campbell; "The Institute and the U. S. Patent System," William M. Grosvenor; "The Practical Value of Calorific Tests on Anthracite Coal," and "Two Methods of Testing Asphalt," S. F. Peckham. Excursions will be made to a number of chemical and industrial works.

ENGINEERS' SOCIETY OF PENNSYLVANIA.—The third annual convention will be held at State College, Pa., June 7-10. The preliminary program includes the following papers: June 8—"Late Improvements in Sanitation and Sewage Disposal," "The Modern Project of Illumination," "Industrial Efficiency." June 9—"The Manufacture of High Grade Iron and Steel," "The System of Organization of Pennsylvania Engineers" (by F. Herbert Snow, Chief Engineer, State Department of Health); "The Control of Public Utilities." Addresses: "Relationship of the Engineering Profession" (by Edwin Earle Clark, L. L. D., President of the Pennsylvania State College); "Scientific Investigation." June 10—"Some Particular Problems for Which the State Engineers are Responsible."

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Engineers in New York City expecting to attend the annual convention at Chattanooga, Tenn., June 13-16, should communicate with Mr. L. J. Ellis, Eastern Passenger Agent of the Norfolk & Western Railway, 355 Broadway, N. Y. City. No special excursion rates have been authorized, but it is planned to organize a party to travel together so as to take advantage of rates usually granted to large parties. If a large enough party is secured, arrangements will be made for a special train.

At the meeting held in New York City, May 17, a paper entitled "The Present Day Pumping Engine for Water Works," by Charles A. Hague, was presented for discussion. This paper was printed in the March "Proceedings."

ASSOCIATION OF FIRE ENGINEERS.—The annual meeting will be held in Milwaukee, Wis., Sept. 19-22. Among the papers to be presented are the following: "Fire Prevention by Education Rather than Legislation," H. C. Henley, St. Louis, Mo., A. V. Bennett, Birmingham, Ala.; "Electrically Propelled Motor Fire Apparatus," W. H. Daggett, Springfield, Mass.; "Gas-Engine Propelled Motor Fire Apparatus," Thos. Ballantyne, Savannah, Ga., Arthur Aungst, Alliance, Ohio; "The Caliber of Fire Streams and a New Method of Determining Their Value," Chas. H. Fox, Cincinnati, Ohio; "Compulsory Sprinkling of Basements," W. H. Loller, Youngstown, Ohio; "Rubber Tires: Solid vs. Pneumatic," Chas. E. Swingley, St. Louis, Mo.; "The Best Method of Selecting Hose for Fire Department Purposes," Harry L. Cremer, Chicago, Ill.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.—Among the committees appointed for the present year are the following: Standards—J. J. Blackmore, Ralph Collamore, Roy E. Lynd, E. A. May and P. H. Seward. Tests—W. H. McKiever, F. T. Chapman, J. A. Donnelly, N. S. Thompson and M. F. Thomas. Heating Guarantees—W. H. Mackay, Thomas Morrin, G. W. Scott, F. C. Goff and C. E. Pearce. School Room Ventilation—F. I. Cooper, C. B. J. Snyder, E. D. Densmore, C. F. Eveleth, and H. W. Whitten. Air Leakage and Ventilation of the Closed Room—Prof. J. H. Kinealy, General Chairman. Massachusetts—H. W. Whitten, R. L. Folsom, D. S. Boyden, Charles Morrison and L. G. Robbins. Pennsylvania—I. H. Francis, Jr., Homer Addams, E. S. Berry, J. E. McGinness and J. P. Schaffer. Missouri—B. C. Davis, H. H. Humphrey, J. M. Kent, F. N. Jewett and Samuel Kauffman. Revision of the Constitution—Prof. William Kent, Prof. R. C. Carpenter, W. G. Snow, S. A. Jellett and F. K. Chew. The first name given in each case is that of the chairman.

AMERICAN WATER WORKS ASSOCIATION.—The program for the third annual convention at Rochester, N. Y., June 6-10, has been announced as follows: June 6—Reports of special and standing committees and the following papers: "Fire Line Meters, A Comparison of Efficiency," George Houston; "Pumping Station Management," Thomas McMillan; "Some Fundamental Considerations in the Determination of a Reasonable Return for Public Hydrant Service," Leonard Metcalf, Emil Kuichling, and W. C. Hawley; illustrated lecture on the Panama Canal by Dabney H. Maury. June 7—Question box and experience meeting followed by papers on "An Emergency Intake," Dr. Wm. P. Mason, and on "Wood Stave Pipe, Some Questions Answered," by T. Chalkley Hatton. June 8—"Water Rates," George G. Earl; "High Pressure Fire Service Compared with Portable Fire Engines," Charles A. Hague; "Compressed Air in Water Works Construction," Alexander Milne; "The Investigation of Underground Water Waste in Washington, D. C.," W. A. McFarland; "Steel vs. Iron Pipe," Allen Hazen; "Hot Water Problems," George C. Whipple; "Interpretation of Chemical and Bacteriological Terms Used in Water Analysis," Daniel D. Jackson; "Methods of Keeping Records of Improvements to Establish Water Works Plants," Charles Carroll Brown. June 9—"Water Softening by Means of Zeolith," Boris N. Simin; "Stripping Reservoir Sites," H. G. Coventry; "Sidney (Australia) Water Supply, Its History and Management," Charles Walter Smith; "Ultra-Violet Ray Sterilization," E. A. Walden.

The annual meeting of the Water Works Manufacturers' Association will be held at the Powers Hotel, Rochester, N. Y., on Thursday, June 8, at 10:30 a. m.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.—The committees for 1911 have been appointed, and the list, with the names of the respective chairmen, is as follows: (1) Roadway, J. E. Willoughby, Engr. of Const., L. & N. Ry., Louisville, Ky.; (2) Ballast, H. E. Hale, Prin. Asst. Engr., Mo. Pac. Ry., St. Louis, Mo.; (3) Ties, L. A. Downs, Supt., Ill. Central Ry., Fort Dodge, Iowa; (4) Rail, C. S. Churchill, Ch. Engr., N. & W. Ry., Roanoke, Va.; (5) Track, J. B. Jenkins, Asst. Engr., B. & O. Ry., Baltimore, Md.; (6) Buildings, Maurice Coburn, Prin. Asst. Engr., Vandalia Ry., St. Louis, Mo.

(7) Wooden Bridges and Trestles, C. C. Wentworth, Prin. Asst. Engr., N. & W. Ry., Roanoke, Va.; (8) Masonry, G. H. Tinker, Bridge Engr., N. Y., C. & St. L. Ry.; (9) Signs, Fences and Crossings, K. J. C. Zinck, Grand Trunk Pacific Ry., Winnipeg, Canada; (10) Signals and Interlocking, A. H. Rudd, Signal Engineer, Pa. Ry., Philadelphia, Pa.; (11) Records and Accounts, H. J. Pfeifer, Engr. M. of Way, Terminal Ry. Assoc., St. Louis, Mo.; (12) Rules and Organization, J. O. Osgood, Ch. Engr., C. Ry. of N. J., Jersey City, N. J.; (13) Water Service, Robert Ferriday, Engr. M. of Way, C., C. C. & St. L. Ry., Indianapolis, Ind.

(14) Yards and Terminals, C. H. Spencer, Engineer, Washington Terminal Co., Washington, D. C.; (15) Iron and Steel Structures, C. H. Cartlidge, Bridge Engr., C., B. & Q. Ry., Chicago; (16) Economics of Railway Location, A. K. Shurtleff, Office Engr., C., R. I. & P. Ry., Chicago; (17) Wood Preservation, Earl Stimson, Ch. Engr. M. of Way, B. & O. Ry., Baltimore, Md.; (18) Electricity, G. W. Kittredge, Ch. Engr., N. Y. Central Ry., New York, N. Y.; (19) Conservation of Natural Resources, E. O. Faulkner, Manager of Tie & Timber Dept., A., T. & S. F. Ry., Los Angeles, Cal.; (20, Special), Uniform General Contract Forms, J. C. Irwin, Ch. Engr., Rutland Ry., Rutland, Vt.; (21, Special), Grading of Lumber, W. H. Sellew, Prin. Asst. Engr., Mich. Cen. Ry., Detroit, Mich.

AMERICAN INSTITUTE OF MINING ENGINEERS.—Members and friends of the institute attended an informal meeting held at the Engineering Societies Building in New York City May 8. Mr. Jennings S. Cox, Jr., General Manager of the Spanish American Iron Co., presented a paper on "Iron Ore Mining in Cuba." It is announced that arrangements will be made for similar meetings in the future to promote a more active intercourse among the members.

An informal meeting of the New York members will be held Friday evening, May 26, to hear an address by Dr. James Douglas on "The Copper Queen Company and the Development of the Warren Mining District, Arizona." The lecture will be preceded by an informal dinner at the Engineers' Club.

At the coming annual meeting at Glen Summit Springs, Pa., June 6-10, papers will be presented as follows: "Geology of the Cobalt District, Ontario, Canada," Reginald E. Hore, Houghton, Mich.; "Origin of Certain Bonanza Silver Ores of the Arid Region," Charles R. Keyes, Des Moines, Iowa; "A Drafting Table for Tracing Through Opaque Paper," A. T. Schwennesen, Stanford University, Cal.; "Lead Smelting on the Ore Hearth," J. J. Brown, Jr., Wilburton, Okla.; "Proposed Code of Rules for the Installation and Use of Electricity in Mines," S. A. Taylor, Pittsburg, Pa.; "The Caddo Oil and Gasfield, Louisiana," Walter E. Hopper, Madison, Wis.; "Origin of Iron Ores of Central and Northeastern Cuba," C. K. Leith, and W. J. Mead, Madison, Wis.; "Occurrence, Origin and Character of the Surficial Iron Ores of Camaguey and Oriente Provinces, Cuba," Arthur C. Spencer, Washington, D. C.; "The Mayari and Moa Iron-Ore Deposits in Cuba," C. Willard Hayes, Washington, D. C.; "Exploration of Cuban Iron-Ore Deposits," Dwight E. Woodbridge, Duluth, Minn.; "The Iron-Ore Deposits of the Moa District, Oriente Province, Island of Cuba," Jennings S. Cox, Jr., Santiago de Cuba, Cuba; "Characteristics and Origin of the Brown Iron Ores of Camaguey and Moa, Cuba," Benjamin L. Miller and Willard L. Cummings, Bethlehem, Pa.; "The Application of the Equation of the Straight Line to the Reduction of Triangulation Readings," L. D. Moore, Holden, W. Va.; "The Fuel Efficiency of the Iron Blast Furnace," John Jermain Porter, Cincinnati, Ohio; "The Continuous System of Cyaniding in Pachuca Tanks," Huntington Adams, Ixtlan de Juarez, Oaxaca, Mex.; "Mining Costs at Park City, Utah," Fred T. Williams, Park City, Utah; "Some Radical Improvements in the Practice of Concentrating Minerals by the Use of Wet Tables," S. Arthur Krom, Plainfield, N. J.; "Electrical Practice in Mines," Burton McCullon, Washington, D. C.; "The Bituminous-Coal Industry," S. K. Smith, Vintondale, Pa.; "History and Geology of Ancient Goldfields in Turkey," Leon Dominian, New York City, N. Y.; "Tunnel Driving in the Alps," W. L. Saunders, New York City, N. Y.; "Briquetting Plant of the Lehigh Coal and Navigation Company," Charles Dorrance, Jr., Lansford, Pa.; "Canadian Mining Law," J. M. Clark, Toronto, Canada; "The Liberty Bell Mine." Charles A. Chase, Denver, Colo.; "The Storage of Anthracite Coal," R. V. Norris, Wilkes-Barre, Pa.; "Anthracite Preparation," Paul Sterling, Wilkes-Barre, Pa.; "Loss in 'Breaking Down' Anthracite," W. F. Dodge, Scranton, Pa.; "The Summit Hill Mine Fire," W. A. Lathrop, Philadelphia, Pa.; "The Anthracite Arbitration Board," S. D. Warriner, Wilkes-Barre, Pa.; "Reminiscences of the Beginning of the Institute," R. W. Raymond, New York City, N. Y.

Besides the regular sessions, there will be excursions to mines, breakers and cold-storage plants, to Lehigh University and to the Bethlehem Steel Works.